EXECUTIVE SUMMARY

This summarizes the U. S. Fish and Wildlife Service's (Service) final report on the fish and wildlife resources likely to be impacted by proposed actions related to the Arkansas River Navigation Study, Arkansas and Oklahoma. This report will accompany the U. S. Army Corps of Engineers' (Corps) feasibility report on this project.

The Little Rock and Tulsa Districts of the Corps are charged with the operation and maintenance of the McClellan-Kerr Arkansas River Navigation System (MKARNS) for commercial navigation. The proposed action is to improve and maintain the MKARNS through three features: 1) River Flow Management, 2) Navigation Channel Deepening, and 3) Navigation Channel Depth Maintenance.

This final report 1) identifies the effects of actions proposed to maintain and improve navigation on the MKARNS on fish and wildlife resources within the project area, 2) discusses measures to appropriately identify, avoid, and minimize environmental impacts, and 3) provides recommendations to appropriately compensate for unavoidable impacts to fish and wildlife resources and to maintain the value of the fish and wildlife resources associated with the navigation system.

The project area consists of the entire 445–mile–long MKARNS in Arkansas and Oklahoma, and 11 upstream multi-purpose reservoirs in Oklahoma that act as the MKARNS's primary flow modifiers. The extensive project area contains a diversity of high quality fish and wildlife resources.

Important fish and wildlife resources are associated with the 11 upstream reservoirs used to regulate flow on the system. These include state wildlife management areas (WMAs) located on the project lands surrounding the reservoirs and managed by the Oklahoma Department of Wildlife Conservation (ODWC), WMAs managed by the Arkansas Game and Fish Commission (AGFC), river oxbows, dike fields, floodplain habitat, bottomland hardwood forest, wetlands, national wildlife refuges, the Arkansas and Verdigris rivers and their tributaries, and numerous federally-listed species.

RIVER FLOW MANAGEMENT

The purpose of the River Flow Management feature of the study is to improve the safety and efficiency of commercial navigation operations, and to reduce flood damages by managing the MKARNS to limit periods of sustained high flows that originate from the upper reaches of the Arkansas River watershed. The effects of modifying the current operating plan were evaluated using the Corps "Southwestern Division Modeling System for the Simulation of the Regulation of a Multipurpose Reservoir System," also known as the SUPER Model. For this evaluation, reservoir elevations and river stages were modeled using a 61 year (January 1940 – December 2000) period of record.

The River Flow Management feature would consist of maintaining the existing operating plan (*i.e*., operating Van Buren at 150,000 cubic feet per second (cfs)), but replacing the current 75,000 cfs bench with a 60,000 cfs bench beginning at 3 percent lower system storage, except from June 15 – October 1. Fluctuations of reservoir water levels under the selected plan are expected to change only slightly from current operations. Based on average annual lake levels and stream flows, impacts to fish and wildlife resources at the reservoirs would appear not to differ significantly from current conditions. The Service believes, however, that it is important to also consider all conditions that would occur in extreme high and low years in order to adequately evaluate potential effects to fish and wildlife resources. Anticipated impacts could include altering the littoral zone, eliminating vegetated areas adjacent to the reservoirs, adversely impacting fish spawning and recruitment, and reducing available habitat for migratory birds.

Implementation of the selected plan also would reduce the duration of flooding in the floodplain downstream of the 11 reservoirs. Because the hydrology of wetlands in the floodplain would be altered, important wetland habitats may be adversely impacted. In order to adequately assess impacts to these wetlands and compensate for unavoidable losses, we recommend that the Corps identify the specific lands that would receive flood protection benefits, determine the quantity (acres) and quality (habitat type and value) of wetlands that the selected operating plan would alter, and determine the quantity (acres) and quality (habitat type and value) of wetlands that would be acquired and/or managed to compensate for wetland losses.

NAVIGATION CHANNEL DEEPENING

The purpose of the proposed Navigation Channel Deepening feature is to remove the disparity between the navigation channel depths of the MKARNS (9 feet) and the Lower Mississippi (12 feet), and thereby increase the volume and efficiency of commercial navigation operations. The proposed action is anticipated to have substantial direct and indirect effects to important fish and wildlife resources. Impacts would include the loss of terrestrial habitat due to the disposal of dredged material in upland sites; the loss of aquatic habitat due to disposal of dredged material in aquatic sites and the construction and raising of river training structures; the removal and alteration of gravel bars, which support a variety of aquatic species, due to dredging activity; and adverse effects on freshwater mussel patches and beds (*i.e.,* mussel concentrations) due to dredging activity and the disposal of dredged material.

Early in the evaluation process, a Multi-agency Ecosystem Evaluation Team was established to evaluate impacts of the proposed Navigation Channel Deepening feature on terrestrial and aquatic habitats and ecological benefits resulting from proposed mitigation measures. The multidisciplinary team included biologists with technical expertise from the Corps, Little Rock and Tulsa Districts, the Service, the Corp's Engineer Research and Design Center, ODWC, AGFC, and Parsons, a private consulting firm. The team evaluated the environmental impacts of proposed dredging and disposal of dredged material using Habitat Evaluation Procedures (HEP).

The HEP were used to conduct assessments at the terrestrial dredged material disposal sites and at selected mitigation sites. The disposal of dredged material at terrestrial sites would result in the loss of about 750 acres of important habitat in Oklahoma, for which compensatory mitigation

is being recommended. Terrestrial dredge disposal sites in Arkansas would occur in cropland sites along the Post Canal, which were selected to avoid impacts to important fish and wildlife habitat. Habitat conditions were projected over the 50-year life of the project. A mitigation plan to offset anticipated impacts was developed through interagency cooperation of biologists with the Corps, Service, and the ODWC. The compensatory mitigation plan currently endorsed by the Service and ODWC consists of bottomland hardwood restoration and marsh creation at two sites along the Verdigris River that are currently agricultural fields.

The entire aquatic impacts analysis has not been completed as of the date of this report due largely to the expedited study schedule and missing information. Certain variables used in the analysis are currently being fine-tuned. Aquatic mitigation features considered to date would result in a net gain of habitat units in Oklahoma, but a deficit in Arkansas. The Corps, Service, and the AGFC have recently developed additional and modified mitigation features for the Arkansas portion of the project. This report provides these additional compensatory mitigation recommendations for aquatic resource impacts for consideration by the Corps during development of a complete mitigation plan. We believe incorporation of these recommendations into the final mitigation plan would serve to completely offset losses in habitat value (see Appendix G).

NAVIGATION CHANNEL MAINTENANCE

The purpose of the proposed Maintenance Dredging and Disposal feature is maintenance of the navigation channel through the continued use of a series of river training structures, as well as maintenance dredging at locations where the channel is less than desired depth due to sediment accumulation. This feature would consist of disposal of dredged material at new sites not included in the original Operation and Maintenance Plan, once existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable. This component also includes new river training structures. Impacts anticipated as a result of the Navigation Channel Maintenance feature are being assessed using the same HEP methodology as described above for the Navigation Channel Deepening element.

FEDERALLY-LISTED SPECIES

Several federally-listed species occur in the project area. Formal consultation under section 7 of the Endangered Species Act (ESA) currently is in progress for the following four species: the interior least tern, American burying beetle, bald eagle, and pallid sturgeon.

The study offers the Corps an opportunity to carry out both section 7 (a) 1 and 7 (a) 2 responsibilities, as mandated by the ESA. Section 7 (a) 1 of the ESA requires that all federal agencies use their authorities to carry out programs for the specific purpose of conserving threatened and endangered species. Island construction for interior least terns using dredged

material could represent one such opportunity. Section 7 (a) 2 responsibilities are addressed in the Service's biological opinion.

MITIGATION AND SERVICE POSITION

Environmental Management Program

The effects of the development, operation, improvement, and maintenance of the navigation system on the fish and wildlife resources in the study area (including the reservoirs, wildlife management areas, the downstream segments of the rivers, wetlands, backwater areas, and in the main stem of the navigation channel) will have long-term consequences that cannot be adequately identified or appropriately assessed without long-term studies and extensive monitoring efforts. The Service believes the Corps should seek Congressional authorization and funding for an Environmental Management Program in order to perform long-term monitoring and resource studies to assess the true magnitude of the development, operation, and maintenance of the MKARNS. The Service also recommends that a mitigation fund be established that would be utilized to address mitigation needs identified through the long-term monitoring program. The cost of the long-term monitoring program and the mitigation fund should be considered in the Corp's benefit:cost analysis for the Arkansas River Navigation Study. Benefits to local economies attributable to expenditures by outdoor recreation enthusiasts, such as wildlife observers, hunters, and anglers, are likely to increase as the quality of habitat supporting fish and wildlife species increases. These benefits to local/regional economies also should be considered.

Unmet Mitigation Needs

The MKARNS is a large and complex system that impacts rivers, tributaries, oxbows, reservoirs, wetlands, and other important natural resources. The original construction of the navigation project destroyed a considerable amount of highly valuable fish and wildlife habitat along the Verdigris and Arkansas rivers. Losses of fish and wildlife habitat as a result of original construction, operation and maintenance of the MKARNS were not evaluated using habitat value as a basis for determining compensation needs. About 28,200 acres of project lands, including the Sequoyah National Wildlife Refuge and McClellan-Kerr WMA units, were allocated for wildlife management after construction of the MKARNS. The Service believes it is reasonably certain that the total combined habitat value lost within the impacted areas far exceeds the habitat value gained from project lands and water licensed and designated for fish and wildlife resource management.

Furthermore, since the initial navigation project was completed, many acres of impacts have been identified that were not accounted for originally. Impacts to these areas were never fully assessed or mitigated during initial navigation project planning or implementation. In addition, the proposed project likely will increase the impacts to these areas. The full extent of unmitigated impacts associated with the original project, and the current proposed project impacts, should be considered within this project assessment and mitigated appropriately.

The Service recommends that the Corps seek Congressional authorization and funding to initiate a study to address any unmet mitigation needs of the original project and implement conservation measures previously recommended by the Service. This study could constitute an initiation of the Environmental Management Program.

Service Position

Fish and wildlife resources and wildlife-associated recreational activities are an important aspect of American culture. In 2001, U. S. residents spent more than $108 billion dollars while pursuing fish and wildlife related activities. In Oklahoma alone, wildlife observers, hunters, and anglers spent $193,248,000, $248,071,000, and $476,019,000, respectively during 2001 (USDOI and USDOC, 2001). In 2002, over 35 million people visited national wildlife refuges. Their expenditures (*e.g.*, lodging, food, equipment) generated over $809 million in regional economies (USFWS, 2003).

The Service's overall mitigation goal is to conserve important fish and wildlife resources for the benefit of the American people, while facilitating balanced development. This goal is supported by language in the Fish and Wildlife Coordination Act (FWCA) and other authorities. The FWCA establishes fish and wildlife conservation as a coequal purpose of water resource development projects and states that fish and wildlife resources shall receive equal consideration with other features of water resources development programs.

The action alternatives for deepening and maintaining the navigation channel would have significant adverse impacts on both terrestrial and aquatic fish and wildlife resources. As of the date of this report, a full assessment of adverse impacts and a complete mitigation plan have been developed for impacts due to disposal of dredged material at terrestrial sites within the floodplain of the navigation system in Oklahoma.

The Corps, Service, ODWC, and AGFC have been in constant and frequent coordination regarding the assessment of impacts the navigation channel deepening would have on aquatic fish and wildlife resources. Unfortunately, due to the extremely expedited schedule for this study, the aquatic impacts analysis has not been completed as of the date of this report. The Service understands that the Corps intends to fully mitigate for aquatic resource impacts. This report provides additional compensatory mitigation recommendations for Corps consideration during development of the final mitigation plan for aquatic resource impacts in Appendix G. We believe that incorporating the additional mitigation features into the mitigation plan should serve to adequately offset aquatic resource impacts. The final mitigation plan for aquatic resource impacts would be acceptable to the Service, ODWC, and AGFC provided that it was demonstrated through a HEP or similar analysis to completely offset losses in habitat value over the project life.

The Service believes that in order to ensure that fish and wildlife resources receive equal consideration, as mandated by the FWCA, the Corps should:

- Develop a final mitigation plan through interagency coordination that would minimize, avoid, and compensate for all project impacts;

- Utilize the authorities provided under section 906(b) Water Resources Development Act (WRDA) 1986 and section 306 WRDA 1990 to seek full Congressional authorization and funding for an Environmental Management Program in order to perform the long-term studies and monitoring of the fish and wildlife resources associated with the navigation system; and

- Establish a mitigation fund that would be utilized to address mitigation needs identified through the long-term monitoring program.

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INTRODUCTION

This Fish and Wildlife Coordination Act Report (CAR) provides information on fish and wildlife resources associated with the McClellan-Kerr Arkansas River Navigation System (MKARNS) for use during the Arkansas River Navigation Study, Arkansas and Oklahoma (ARNS). This study is being conducted by the U. S. Army Corps of Engineers (Corps) to investigate maintenance and improvement of commercial navigation on the MKARNS.

The development of the Arkansas River and its tributaries for the purposes of navigation, flood control, hydropower, water supply, recreation, and fish and wildlife habitat was initially authorized by the Rivers and Harbors Act of July 24, 1946. Public Law 91-649 stated the project would be known as the McClellan – Kerr Arkansas River Navigation System. Development of and construction on the MKARNS began in 1957 and was completed in 1971.

The current study results from an March 11, 1982, Resolution by the Committee on Public Works and Transportation of the U. S. House of Representatives dated March 11, 1982, known as the Arkansas River Basin Study Authority. This resolution authorized the Corps to examine proposals for storage, conservation, treatment, and conveyance of water in the Arkansas River and Tributaries in Arkansas and Oklahoma for municipal and industrial uses. The resultant reconnaissance study that began in 1984 recommended that more detailed feasibility level studies be conducted to solve navigation, flood control, recreation, water supply, and fish and wildlife resource problems in the Arkansas River Basin in Arkansas and Oklahoma. Funds were provided in the Energy and Water Development Appropriations Act of 1999 to perform a reconnaissance study of the flooding problems in the vicinity of Fort Smith, Arkansas. As a result of the reconnaissance study, a section 905(b) analysis in accordance with the Water Resources and Development Act (WRDA) of 1986 was prepared by the Southwest Division Corps. The report recommended the current feasibility study with two phases, and was approved by the Corps Headquarters on January 4, 2000.

The Corps completed a draft Feasibility Report and Environmental Impact Statement for Phase 1 in August 2003. The purpose of Phase 1 was to investigate possible operational changes that might improve the MKARNS's ability to evacuate high water through the system and reduce impacts of sustained high flows. The purpose of Phase 2 was to investigate the feasibility of deepening the entire length of the MKARNS from 9 to 12 feet where necessary to allow for deeper tow drafts. Phase 2 also would have been used to investigate adding passing lanes on the Verdigris River in Oklahoma for increased tow safety. However, the Corps decided to combine the two phases into a single comprehensive study based on comments received during the National Environmental Policy Act scoping process for Phase 1 and Phase 2 (Notice of Intent published in the July 16, 2004, issue of the 136 FR 42549).

The purpose of the comprehensive ARNS was to identify and evaluate environmental and socioeconomic aspects of viable alternatives to improve the productivity of commercial navigation on the MKARNS while maintaining the other project purposes of flood control, recreation, hydropower, water supply, and fish and wildlife. The alternatives evaluated in detail are associated with three major elements related to the maintenance and improvement of the

MKARNS, and, therefore, influence navigation on the system. The three elements considered in this study are: 1) River Flow Management, 2) Navigation Channel Deepening and 3) Navigation Channel Maintenance.

The purpose of the River Flow Management element is to develop and evaluate various modifications to the MKARNS that would resolve specific socioeconomic problems resulting from sustained high flows that originate from the middle reaches of the Arkansas River watershed. These problems include flood damages along the river, decreased navigation traffic, and losses to recreational use.

The study team initially examined eight structural alternatives and 23 non-structural alternatives, including altering the current reservoir regulation plan, to facilitate operational changes to the MKARNS in Oklahoma. These alternatives examined measures such as modification of reservoir releases to enable changes in flow rates and durations, reallocating storage from one reservoir to another, or adding storage in the reservoirs. Other alternatives included constructing additional reservoirs, additional high flow relief structures (i.e., spillways), and additional levees along the MKARNS, as well as adjustments/increases in flowage easements, removal of channel restrictions, in-stream modification of existing navigation structures, and restoration/ enhancement of aquatic and riparian habitat along the MKARNS. The study team determined that structural alternatives would be too expensive relative to the associated benefits and would not adequately meet the study objective. From the 23 non-structural alternatives evaluated, four operational alternatives were examined in detail. The detailed analysis for each of the four operational alternatives included a hydraulics study, hydrologic modeling of the river system, and an economics study for each proposed alternative.

The purpose of the Navigation Channel Deepening feature was to determine the feasibility of deepening the MKARNS to improve efficiency and productivity of commercial navigation. The existing 9-foot draft channel limits towboat loads when compared with loads supported by the 12-foot draft channel of the Lower Mississippi River. The disparity between the channel depths of the two systems is believed to result in less efficient operations than could be achieved with a consistent 12-foot navigation channel depth throughout the two systems. Channel deepening has been proposed to occur in six river segments: 1) mouth to Pine Bluff, 2) Pine Bluff to Little Rock, 3) Little Rock to Dardanelle, 4) Dardanelle to Ft. Smith, 5) Fort Smith to Muskogee, and 6) Muskogee to Catoosa. Alternatives considered include a 10-, 11-, and 12-foot channel depth. However, only the 12-foot channel depth would address the channel disparity between the Mississippi River and the MKARNS.

The purpose of the Navigation Channel Maintenance feature is to maintain the desired navigation channel depth (currently 9-feet) through the continued use of a series of river training structures and maintenance dredging. Dredging would be required to continue ongoing operation of the existing 9-foot navigation channel. Ongoing channel maintenance activities since completion of the MKARNS in 1971 have resulted in previously authorized dredged material disposal sites reaching capacity. Six new disposal sites will be required to accommodate continued channel maintenance activities.

This report provides the U. S. Fish and Wildlife Service's (Service), in cooperation with the Oklahoma Department of Wildlife Conservation (ODWC) and Arkansas Game and Fish Commission (AGFC), evaluation of likely impacts to fish and wildlife resources as a result of possible structural and operational changes to the MKARNS in Oklahoma and Arkansas. Specifically, this report is intended to 1) identify the effects of river flow management, channel deepening, and navigation channel depth maintenance alternatives on fish and wildlife resources within the project area; 2) discuss measures to avoid and minimize environmental impacts; and 3) provide recommendations to appropriately compensate for unavoidable impacts to fish and wildlife resources.

This CAR has been prepared under the authority of and in accordance with the Fish and Wildlife Coordination Act (FWCA; 48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and fulfills the reporting requirement set forth in section 2(b) of the FWCA. The CAR is intended to accompany the Corps report on the feasibility of adopting one of four river flow and channel deepening alternatives for the MKARNS that are intended to improve commercial navigation. This report has been coordinated with the ODWC and the AGFC, and has their support as indicated in Appendix A.

The Service (Oklahoma and Arkansas field offices) previously provided an evaluation of resources likely to be affected by proposed improvements to the MKARNS in planning aid reports (PAR) dated September 24, 1985, May 13, 1986, June 23, 1988, February 23, 1989, and a CAR dated December 21, 1989. We provided an overview of the existing fish and wildlife resources associated with the MKARNS, addressed possible impacts to fish and wildlife resources, discussed unmet mitigation needs associated with the initial development of the MKARNS, and provided preliminary recommendations for fish and wildlife habitat restoration projects for the present feasibility study in a planning aid report dated April 2, 2001. Planning assistance letters dated September 29, 2003 (pertaining to anticipated project impacts and assessments); March 1, 2004 (pertaining to our concerns regarding the expedited schedule for impact analysis, EIS completion, and implementation); May 5, 2004 (pertaining to aquatic habitat assessment methodology); June 15, 2004 (pertaining to dredging, dredge disposal sites, and mitigation for dredge disposal impacts); and April 29, 2005 and May 11, 2005 (both pertaining to freshwater mussel impacts and mitigation) also have been provided. A preliminary draft CAR dated February 25, 2005, also was provided.

PROJECT AREA

The following description of the project area is derived largely from the ecoregions (*i.e.*, large geographic divisions based on natural communities, geology, and land use) as mapped by Omernik (1995), and on the recent conservation assessments of the terrestrial and freshwater ecoregions of North America undertaken by the World Wildlife Fund (Abell *et al.*, 2000; Ricketts *et al.*, 1999). These assessments divide the continent into coarse terrestrial and freshwater ecoregions similar to other classification schemes such as Kuchler (1975), and Bailey (1994), and describe the biodiversity of each area as well as the threats that each ecoregion currently faces.

The project area for this study encompasses the entire 445–mile–long MKARNS in Arkansas and Oklahoma (Figure 1), and the 11 upstream multi-purpose reservoirs in Oklahoma that act as the MKARNS's primary flow modifiers (Table 1). The series of locks, dams, and reservoirs associated with the MKARNS facilitate inland navigation and provides flood control, hydroelectric power, water supply, and recreational activities such as boating, camping, fishing, hunting, and hiking. The 11 upstream reservoirs can store about 7.7 million acre-feet of water for flood control. Each reservoir has specific purposes as authorized by Congress (Table 1). Although the Corps has broad authority to modify the operations of the reservoirs to benefit navigation, operational plans of the reservoirs cannot be changed in a way that is detrimental to their authorized purpose. Navigation is an authorized purpose for only three reservoirs (Oologah, Keystone, and Eufaula). Runoff from a 7,500 square mile drainage area below the 11 reservoirs and above Van Buren, Arkansas, is uncontrolled.

FOUR SEGMENTS OF THE MKARNS

The MKARNS consists of four distinct segments: 1) 50 miles of the Verdigris River in Oklahoma (RM 445 - 394), 2) 375 miles of the Arkansas River proper in Oklahoma and Arkansas (RM 394 - 19), 3) the manmade Arkansas Post Canal (RM 19 -10), and 4) the White River entrance channel (RM 10 - 0) at the confluence of the White and Mississippi Rivers in Desha County, Arkansas.

The head of the MKARNS is the Port of Catoosa in Rogers County, Oklahoma near Tulsa (navigation mile (NM) 444.8). From this port, the MKARNS follows the Verdigris River for 50 miles southeasterly through the Newt Graham Lock and Dam (# 18 at NM 421.4) and the Chouteau Lock and Dam (# 17 at NM 401.4) in Wagoner County. This area of Oklahoma is in the Central Forest/Grassland Transition Zone terrestrial ecoregion (CTZ) (Ricketts *et al.* 1999) and the Central Prairie freshwater ecoregion (Abell *et al.* 2000). The area is includes portions of Omernik's (1995) Central Irregular Plains and Central Oklahoma/Texas Plains. The Arkansas, Grand, Verdigris, Cimarron, and Canadian Rivers each drain portions of this area of Oklahoma.

Oologah, Keystone, Copan, Fort Gibson, Hudson, and Eufaula Reservoirs are all located in this portion of the project area, which consists primarily of a mixture of prairie, savannah, and woodlands on low rolling hills, and broad floodplain forests of elm *Ulmus* spp., oak *Quercus* spp., hackberry *Celtis occidentalis*, cottonwood *Populus deltoides*, and sycamore *Platanus occidentalis* created by slow-moving and muddy tributaries. The CTZ grasslands predominantly occur on relatively deep and fertile soils with the exception of those occurring on the thin layer of soil over limestone that occurs in the Flint Hills Tall Grasslands (Ricketts *et al.*, 1999) to the northwest (location of Hulah Reservoir). A greater average annual precipitation in the CTZ results in higher densities

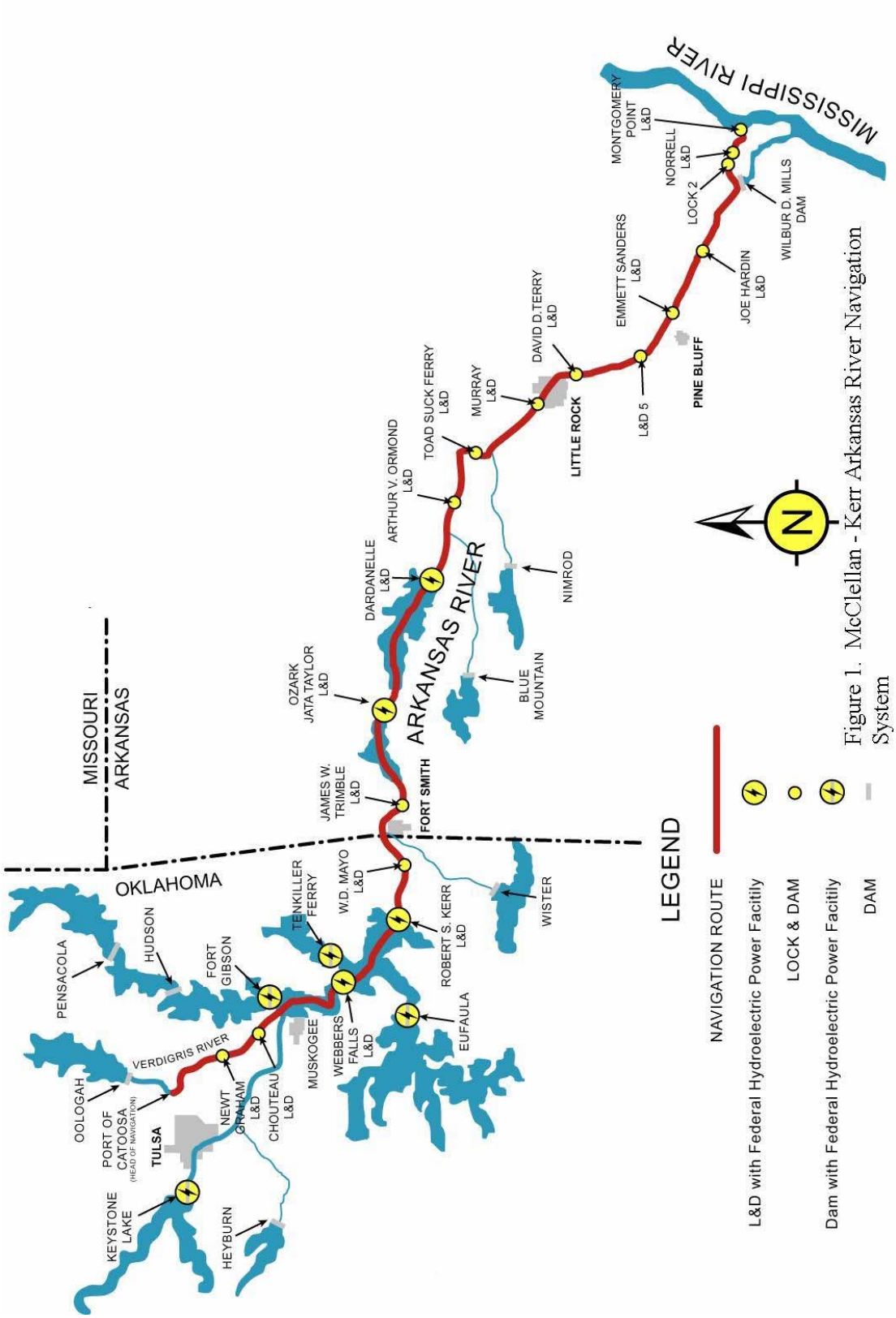

Figure 1. McClellan - Kerr Arkansas River Navigation System

Table 1. Information on the 11 upstream reservoirs in Oklahoma (U.S. Fish and Wildlife Service, 1985; Oklahoma Water Resources Board; 1990).

Reservoir	Agency	Counties	River/Stream and Purpose of Reservoir	Flood Storage (acre-feet)	Conservation pool(acres)/ elevation (NGVD)	Flood pool(acres)/ Elevation (NGVD)	Drainage area (sq. miles)	Shoreline length (miles)
Copan	Corps	Washington	Little Caney River; flood control, water supply, water quality control, recreation, fish and wildlife	184,300	4,850/710.0	13,380/732.0	505	30
Hulah	Corps	Osage	Caney River; flood control, water supply, low-flow regulation, conservation	257,900	3,570/733.0	13,000/765.0	732	62
Oologah	Corps	Nowata, Rogers	Verdigris River; flood control, water supply, navigation, fish and wildlife	965,600	29,460/638.0	56,800/661.0	4,339	180
Kaw	Corps	Kay, Osage	Arkansas River; flood control, water supply, water quality, recreation, fish and wildlife	919,400	17,040/1, 010.0	38,020/1, 044.5	46,530	168
Keystone	Corps	Osage, Creek, Pawnee, Tulsa	Arkansas and Cimarron River; flood control, water supply, hydroelectric power, navigation, fish and wildlife	1,180,000	23,610/723.0	54,320/754.0	74,506	330
Grand	Corps/ GRDA	Ottawa, Delaware, Mayes	Neosho and Spring River; flood control, hydroelectric power	525,000	46,500/745.0	59,200/755.0	10,298	1,300
Hudson (Markham Ferry)	Corps/ GRDA	Mayes	Neosho River; flood control, hydroelectric power	244,210	10,900/619	18,800/636	11,533	200

Table 1 Continued

Reservoir	Agency	Counties	River/Stream and Purpose of reservoir	Flood Storage (acre-feet)	Conservation pool(acres)/ elevation (NGVD)	Flood pool(acres)/ Elevation (NGVD)	Drainage area (sq. miles)	Shoreline length (miles)
Fort Gibson	Corps	Mayes, Wagoner, Cherokee	Neosho River; flood control, hydroelectric power	919,200	19,900/554.0	51,000/582.0	12,492	225
Tenkiller	Corps	Cherokee, Sequoyah	Illinois River; flood control, hydroelectric power	576,700	12,900/632.0	20,800/667.0	1,610	130
Eufaula	Corps	McIntosh, Pittsburg	North Canadian, South Canadian, and Deep Fork; flood control, water supply, hydroelectric power, navigation, fish and wildlife	1,510,800	105,000/585.0	143,000/597.0	47,522	600
Wister	Corps	LeFlore	Poteau River and Fourche Maline Creek; flood control, water supply, low flow augmentation, water conservation, sedimentation	386,800	7,333/478.0	23,070/502.5	993	115

of trees and shrubs relative to the Central and Southern Mixed Grasslands (Ricketts *et al.*, 1999) of central and western Oklahoma (location of Kaw Reservoir).

Typical grasses of the CZT include big bluestem *Andropogon gerardii*, little bluestem *Schizachyrium scoparium*, Indian grass *Sorghastrum nutans*, switchgrass *Panicum virgatum*, and grama grasses *Bouteloua spp*. Upland forests dominated by oak Q*uercus spp*. and hickory *Carya spp.* occur in the more mesic draws and ravines. The "crosstimbers" (wide belt of timber on the prairie encountered by explorers as they crossed the plains) also occur in this area on light colored sandy soils with reddish clay subsoils, and consist of hickory trees scattered among short post oak *Q. stellata* and blackjack oaks *Q. marilandica*. Considered one of the most biologically diverse areas in North America because of its large size and proximity to both the great plains and eastern deciduous forests, this region is within the top 10 ecoregions nationally for bird, reptile, and tree species diversity (Ricketts *et al.*, 1999). Much of the fauna is shared with the adjacent grassland ecoregions (prairie species can be found in the woodland understory layer).

The major aquatic habitat types are temperate headwaters and lakes. Endemism for aquatic species is relatively low (Abell *et al.*, 2000).

Only 1 percent of the area is thought to be intact as a result of intensive farming for crops such as corn and soybeans. The degree of terrestrial habitat fragmentation is ranked as extremely high (Ricketts *et al.*, 1999).

The MKARNS joins the Arkansas River northeast of Muskogee in Muskogee County, Oklahoma (NM 395.0). The MKARNS then extends southeasterly through Oklahoma toward Arkansas through Webbers Falls Lock and Dam (# 16 at NM 366.6) creating the 34.5 mile-long Webbers Falls Reservoir in portions of Muskogee, Wagoner, and Cherokee Counties. Webbers Falls impounds 28 miles of the Arkansas River to the mouth of the Verdigris River and then 6.5 miles up the Verdigris to Chouteau Lock and Dam (USFWS, 1983).

From Webbers Falls Lock and Dam, the river channel forms a portion of the county line between Sequoyah/Muskogee and Sequoyah/Haskell Counties near the Sequoyah NWR (described below), and then extends through Robert S. Kerr Lock and Dam (# 15 at NM 336.2) creating Robert S. Kerr Reservoir. Kerr Reservoir forms many irregular arms and peninsulas and extends about 32.7 navigation miles upstream to Webbers Falls Lock and Dam. From Kerr Reservoir, the river continues along the Sequoyah/LeFlore County line through W. D. Mayo Lock and Dam (# 14 at NM 319.6), where it leaves Oklahoma and enters Arkansas. The MKARNS then flows through the James W. Trimble Lock and Dam (# 13 at NM 292.8) along the Crawford/Sebastian County line, and through the Ozark – Jeta Taylor Lock and Dam (# 12 at NM 256.8) in Franklin County, creating Ozark Lake. Continuing southeasterly along the Johnson/Logan County line, the MKARNS forms Lake Dardanelle at Dardanelle Lock and Dam (# 10 at NM 205.5), and then flows along the Yell/Pope County lines, abutting the northern border of Holla Bend NWR (described below). From there, the river flows through Arthur V. Ormond Lock and Dam (# 9 at NM 176.9) in Conway County and along the Conway/Perry and Faulkner/Perry County lines where it extends through Toad Suck Ferry Lock and Dam (# 8 at NM 155.9). The MKARNS

continues along the Faulkner/Pulaski County lines, and through the Murray Lock and Dam (# 7 at NM 125.4) in Pulaski County near Little Rock.

This area of Oklahoma and Arkansas lies within the Ozark Mountain Forests terrestrial ecoregion as defined by Ricketts *et al.* (1999) and the Central Prairie freshwater ecoregion near Muskogee, Oklahoma, to the Oklahoma/Arkansas state line, where the project area enters the Ozark Highlands freshwater ecoregion as defined by Abell *et al.* (2000). These ecoregions are a combination of Omernik's (1995) Ouachita Mountains (location of Wister Reservoir), Ozark Mountains (location of Grand and Tenkiller Reservoirs), and Arkansas Valley ecoregions (with the Arkansas Valley occurring between the others). The Arkansas River floodplain is confined to the Arkansas Valley ecoregion. Other major rivers in this broad area include the Grand (Neosho), Illinois and Poteau Rivers in Oklahoma and the Petit Jean, Fourche Lafave, Mulberry, and Ouachita Rivers in Arkansas.

The natural communities of the area include bottomland hardwood forests along rivers and streams, oak – hickory forests in upland sites, shortleaf pine savannas and mixed pine – hardwood forests on ridge tops, and scattered tallgrass prairie communities in the valley between the dry upland forests and more mesic bottomland hardwood forests. The limestone formation (karst geology) in the northern portion of the area (Ozarks) has dissolved in many places, forming caves.

Many of the natural communities of the project area have been greatly altered by timber harvesting, cultivated agriculture, and development of the MKARNS. Riparian habitat along the Arkansas River is considered severely degraded, and only about 3 percent of the pre-settlement habitat is intact as a result of agriculture, logging, fire suppression, and grazing (Ricketts *et al.*, 1999). Several near-endemic herpetofauna species are found in this area including Strecker's chorus frog *Pseudacris streckeri*, the ringed salamander *Ambystoma annulatum* (Abell *et al.*, 2000) and the many-ribbed salamander *Eurycea multiplicata* (Conant and Collins, 1991).

From Little Rock, the MKARNS continues southeasterly through the David D. Terry Lock and Dam (# 6 at NM 108.1) in Pulaski County and through Lock and Dam (# 5 at NM 86.3) in Jefferson County. The MKARNS then flows through Emmet Sanders Lock and Dam (#4 at NM 66.0) northeast of Pine Bluff. From there, the MKARNS continues through Joe Hardin Lock and Dam (# 3 at NM 50.2) along the Jefferson/Lincoln County Line, and along the Arkansas/Lincoln and Arkansas/Desha County lines. The channel then extends through Lock (# 2 at NM 13.3) and Norrell Lock and Dam (# 1 at NM 10.3) as it follows the nine mile manmade Arkansas Post Canal in Arkansas County that connects the White and Arkansas Rivers. Finally, ten miles of the White River in eastern Arkansas (mile 599 on the Mississippi River) make up the MKARNS's entrance channel from the Mississippi.

This lower reach of the MKARNS is within the Mississippi Embayment freshwater ecoregion (Abell *et al.*, 2000) and the Mississippi Lowland Forest terrestrial ecoregion (Ricketts *et al.*, 1999). In Arkansas, this is identical to Omernik's (1995) Mississippi Alluvial Plain. Other major rivers in the area are the White and Mississippi Rivers. Wetland areas, oak-hickory-pine forests, and bottomland hardwoods once dominated the landscape; however, these habitats have

been extensively altered resulting in the loss of most (91–95 percent) of the original riparian and bottomland forest systems. Much of the remaining floodplain forests include river swamp forests, forests of backwater areas and flats, and upland transitional forests. Most of the remaining habitat is restricted to wet areas that are difficult or not feasible to exploit economically through cultivation or other means (Ricketts *et al*., 1999). The biological distinctiveness of the Mississippi Embayment is considered globally outstanding (*i.e.*, the biological diversity of the area is equaled or surpassed in only a few other places worldwide) (Abell *et al*., 2000).

ELEVEN OKLAHOMA RESERVOIRS

Water flow and storage on the MKARNS is influenced primarily by the following 11 Oklahoma reservoirs: Copan, Hulah, Oologah, Kaw, Keystone, Pensacola (Grand), Hudson (Markham Ferry), Fort Gibson, Tenkiller Ferry, Eufaula, and Wister (Table 1). Collectively, storage by these reservoirs represents more than 70 percent of total flood control storage in the basin. The reservoirs modify flow within the system through controlled water releases through spillways and power generating units (for those reservoirs with hydropower capabilities). Water releases depend on numerous complex factors such as weather conditions, water storage capacity, inflow rates, river flow rates downstream, power requirements, and navigation water requirements. Brief information specific to each reservoir is provided below. A summary of reservoir characteristics (*e.g.*, reservoir purpose, drainage area, storage capacity, etc.) was previously provided in Table 1.

Copan Lake: This reservoir is located in Washington County on the Little Caney River, a tributary of the Caney River, at river mile 7.4 in the Verdigris River watershed. Copan Lake was authorized by the Flood Control Act approved October 23, 1962. Construction began in 1972 and the project was in full operation in 1983. The reservoir is located in the CTZ among gently rolling hills forested with oak, hickory, and other small hardwood trees, tall grass prairie habitat, and bottomland hardwoods. Copan Lake was constructed by the Corps for flood control, water supply, water quality control, recreation, and fish and wildlife. The normal pool area is 4,850 acres. The drainage area is about 505 square miles (Oklahoma Water Resources Board, 1990).

Hulah Lake: Located in the Verdigris watershed at river mile 96.2 on the Caney River in Osage County, this lake was constructed by the Corps under the authority of the Flood Control Act approved June 22, 1936, for flood control, water supply, low-flow regulation, and conservation. Construction began in 1946 and the project was completed in 1951. The normal pool is 3,570 acres. The total drainage area is 732 square miles (Oklahoma Resources Board, 1990). The reservoir is located in the Flint Hills Tall Grasslands ecoregion (Ricketts *et al*., 1999). The area surrounding the reservoir is characterized by rolling hills with a habitat mixture of oak woodlands, prairie, and bottomland hardwoods.

Oologah Lake: Oologah Lake is located on the Verdigris River within the CTZ. The lake was authorized by the Flood Control Act approved June 28, 1938. Construction began in 1950. The project was in full operation in 1974. The Corps constructed the project for flood control, water

supply, and navigation. Oologah Lake is considered a key unit in the flood control plan for the Arkansas River Basin. The normal pool area is 56,800 acres. The drainage area consists of 4,339 square miles (Oklahoma Water Resources Board, 1990).

Kaw Lake: Kaw Lake was authorized by the Flood Control Act approved October 23, 1962. Construction began in 1966. The project was in full operation in 1976. The reservoir is located in the Flint Hills Tall Grasslands ecoregion (Ricketts *et al*., 1999). The lake was constructed by the Corps for flood control, water supply, water quality, recreation, and fish and wildlife. The normal pool is about 17,000 acres. The drainage area is 46,530 square miles (Oklahoma Water Resources Board, 1990).

Keystone Lake: Keystone Lake was constructed by the Corps on the Arkansas River in Osage, Pawnee, Creek, and Tulsa Counties, near the confluence with the Cimarron River, for flood control, water supply, hydroelectric power, navigation, and fish and wildlife. Keystone Lake was authorized by the Flood Control Act approved May 17, 1950. Construction began in 1957. The project was completed in 1964. The drainage area is 74,506 square miles and the normal pool is 23,610 acres (Oklahoma Water Resources Board, 1990).

Grand Lake: Grand Lake was authorized by the Grand River Dam Authority Enabling Act of 1935 which created the Grand River Dam Authority (GRDA). The GRDA is responsible for construction and operation of dams on the Grand River for the purpose of flood control and hydroelectric power production. The project was initiated in 1936 and was completed in 1940. The reservoir begins at the Pensacola Dam on the Grand (Neosho) River in Mayes County and extends northeast into Delaware and Ottawa Counties in the far western portion of the Central Hardwoods Forest (Rickets *et al*., 1999). Grand Lake was constructed by the GRDA for flood control and hydroelectric power. The Flood Control Act of 1944 mandated that the Corps minimize downstream flooding. As a result, the reservoir is jointly operated by the GRDA and the Corps. The Corps controls all releases when the reservoir water levels is above the conservation pool elevation (745 msl). The total drainage area of the lake is 10,298 square miles. The normal pool is 46,500 acres.

Hudson Lake: The reservoir (also known as Markham Ferry) was authorized by the Flood Control Act approved August 18, 1941. The GRDA initiated construction of the project in 1954. Hudson Lake was constructed on the Grand River near Locust Grove in Mayes County, Oklahoma, by the GRDA for flood control and hydroelectric power. Construction was completed in 1964. As with Grand Lake, the project is jointly operated by the GRDA and the Corps, with the Corps controlling all releases when the reservoir water surface level is above the conservation pool elevation. The normal pool for the lake is 10,900 acres. The drainage area is 11,533 square miles (Oklahoma Water Resources Board, 1990).

Fort Gibson Lake: This reservoir was authorized by the Flood Control Act approved August 18, 1941. Construction began in 1942 but was suspended due to World War II until 1946. The project was completed in 1953. Fort Gibson Lake is located on the Grand River in Mayes, Wagoner, and Cherokee Counties, about 7.7 miles above the confluence of the Grand and Arkansas Rivers. The reservoir extends upriver to Lake Hudson, and has a drainage of about

12,500 square miles. The conservation pool covers 19,900 acres (Oklahoma Water Resources Board, 1990).

Tenkiller Ferry: Tenkiller Ferry Lake was authorized by the Flood Control Act approved June 28, 1938. Construction began in 1947 and was completed in 1953. The project is located in the Ozark Mountain Forest ecoregion (Ricketts *et al*., 1999) on the Illinois River in Cherokee and Sequoyah Counties. The reservoir was constructed for flood control and hydroelectric power. The lake drains a 1,610-square mile drainage area. The surface area at the top of the conservation pool is 12,900 acres (Oklahoma Water Resources Board, 1990).

Eufaula Lake: The reservoir was authorized by the River and Harbors Act approved July 24, 1946. Authorized project purposes are flood control, water supply, hydroelectric power, and navigation. Construction began in 1956. The project was in full operation in 1964. The dam is located on the Canadian River in McIntosh County. The reservoir occurs in portions of McIntosh, Pittsburg, Okmulgee, and Haskell Counties. The North Canadian, Canadian, and Deep Fork Rivers converge near the center of the reservoir. The reservoir drains a 47,522-square mile area. The surface area for the conservation pool is about 105,000 acres (Oklahoma Water Resources Board, 1990). Eufaula Lake is the largest reservoir in Oklahoma.

Wister Lake: Wister Lake was authorized by the Flood Control Act approved June 28, 1938. Wister Lake was constructed for flood control, water supply, low flow augmentation, water conservation, and sedimentation. Construction began in 1946. The project was in full operation in 1949. The dam is located on the Poteau River about two miles south of Wister in LeFlore County. The reservoir is located in LeFlore and Latimer Counties, and drains a 993-square mile area (Oklahoma Water Resources Board, 1990). The basic topography of the area is rough, varying from low rounded ridges on the north and northeast to high mountainous ridges in the south, southwest, and central portions of the watershed. The surface area for the conservation pool is about 7,400 acres.

GEOLOGY, SOILS, AND CLIMATE

The geology of the project area is quite variable. Quaternary sand, silt, clay, and gravel occur in the floodplains and terrace deposits of the major rivers (*i.e*., Arkansas, Verdigris, and White Rivers). Mississippian and Devonian-Silurian marine limestone, sandstone, and shale occur in the Ozark region where karst features such as caves, sinkholes, and underground streams are common. Thick, complexly folded conglomerates of shale, sandstone, limestone and coal characterize the geology of the Ouachita Mountains (Arkansas Geological Commission, 1997; Miser, 1954).

Soil types found in the project area also are quite variable as a result of subsoil variations and climatic differences. Soils vary from rich prairie loams to heavy clay to thin soils overlying bedrock. Alluvial soils are located throughout the project area along the major drainages. Soils in the Ozarks in northeastern Oklahoma and northwestern Arkansas range from sandy loams to heavy clays to rock outcrops. In the southeastern portion of the study area in Arkansas, soil

types range from loamy soils along bayou ridge tops to predominantly clay in lower elevations. A more detailed description of soils within the project area can be found in the Natural Resources Conservation Service's Soil Survey publications for the various Counties.

The climate is primarily influenced by movement of moist air from the Gulf of Mexico, hot and dry air from the desert southwest, and cold air from the Arctic. The region undergoes seasonal variations in temperature and precipitation and typically experiences long, humid summers and short, mild winters. Mean annual precipitation increases from west to east and ranges from 36 inches near Keystone Reservoir west of Tulsa, Oklahoma, to 54 inches in eastern Arkansas at the Arkansas River's confluence with the Mississippi River. Average annual temperatures range from about 60–62^{o} Fahrenheit, and the growing season varies from 209 days in the grasslands and crosstimbers of Oklahoma to about 220 days in the Mississippi Alluvial plain of eastern Arkansas.

PROJECT DESCRIPTION

The purpose of the current operating plan for the navigation system is to optimize benefits for navigation, flood control, water supply, fish and wildlife, hydropower, and recreation while minimizing adverse impacts to the environment, farmland, and fish and wildlife resources. The proposed action is to maintain and improve the MKARNS to benefit commercial navigation on the system while maintaining the other project purposes. The alternatives evaluated in detail are associated with three major project features that influence navigation on the system: 1) River Flow Management, 2) Navigation Channel Deepening, and 3) Navigation Channel Maintenance.

RIVER FLOW MANAGEMENT FEATURE

Flows on the MKARNS are modified primarily by Corps operation of the 11 reservoirs in Oklahoma. Each reservoir is linked through their releases to the main stem of the Arkansas River. Each reservoir is not only operated for local conditions but also must be operated as part of the larger system in conjunction with the other controlling reservoirs. The reservoirs are collectively operated to maintain flow targets at the Van Buren, Arkansas, gage because all the regulated flow releases pass this gage. Channel capacity at Van Buren is 137,000 cubic feet per second (cfs) and is the primary control point for the Lower Arkansas River Basin.

For their analysis, the Corps designated flow rates as optimum, moderate, high, or very high based on the flow rate's effect on commercial navigation and farming operations:

- Optimum: River flows less than 61,000 cfs, which correlates to optimum conditions for commercial navigation.

- Moderate: River flows between 61,000 and 100,000 cfs. Under this flow rate, flooding of some cultivated fields along the main stem of the Arkansas River in western Arkansas begins. Agricultural damages have historically occurred in the Van Buren area when

river flows exceed 61,000 cfs. Warnings are issued to operators of small, recreational water crafts when flows exceed 70,000 cfs.

- High: Flow rates between 100,000 and 175,000 cfs. Any flow above 100,000 cfs renders the system non-navigable for commercial barge traffic, and commercial barge traffic is suspended until flows decrease. The 137,000 cfs flow rate represents bank full discharge at Van Buren.

- Very High: Flow rates greater than 175,000 cfs.

OPERATIONAL HISTORY AND SPECIFIC PROBLEMS

The Arkansas River basin encompasses a drainage area of about 138,000 square miles. Forty-eight Federal and two State (Oklahoma) water resource development projects have been constructed on the Arkansas River from the 1940's to the 1980's. The projects have a variety of purposes such as hydropower, water supply, sediment control, navigation, recreation, fish and wildlife, and flood control.

Water storage in the 11 Oklahoma reservoirs represents more than 70 percent of the total flood control storage in the basin. Runoff from about 7,500 square miles of land below the 11 Oklahoma reservoirs and above Van Buren, Arkansas, is uncontrolled.

Construction of the navigation system itself began in 1957. The MKARNS was constructed to enable large vessels to overcome the steep slope of the Arkansas River Valley due to the 420-foot difference in elevation from the Mississippi River to the head of the MKARNS near Catoosa, Oklahoma. The Corps currently maintains a minimum channel depth of nine feet on the system, a minimum width of 250 feet, and a normal current velocity range between two and four miles per hour. There are 18 existing locks and dams on the MKARNS (all 110 feet wide by 600 feet long). Five occur in Oklahoma and 13 occur in Arkansas. The navigation system was completed in 1970 with the development of the Port of Catoosa, Oklahoma. Since that time, the Corps has modified the operating plan of the system to improve the flow regime for navigation.

Flows on the MKARNS are highly influenced by the storage and release of water in the 11 Oklahoma reservoirs. Initially, the existing reservoirs on the system were operated to achieve a target flow of 150,000 cfs at the Van Buren gage. Under this operating plan, shoaling would occur in the river after a flooding event due to rapid recession of flow. The shoaling would restrict navigation until maintenance dredging could occur. A tapered operation that required water to be retained in the flood control pools for longer periods of time was needed to more gradually reduce flows after a flooding event.

Flows at Van Buren depend on the season of the year and percent of flood control storage being utilized. Seasonal guide curves were developed to aid the Corps in regulating flows at Van Buren. The guide curves related flows at Van Buren with the percent of flood control storage

being utilized plus three days of forecasted inflow into the 11 controlling reservoirs. To meet the intended objective, a delay in evacuation of the lower portion of the flood control storage would occur. The amount of delay depends on the time of year, hydrologic conditions in the basin, and the amount of flood control storage in the 11 controlling reservoirs. Four release zones were used: 1) 150,000 cfs, 2) 150,000 to 105,000 cfs, 3) 105,000 to 40,000 cfs, and 4) 40,000 to 20,000 cfs. The system was operated under this "Van Buren Guide Curve Plan" from 1979 to 1986.

Successive high flow events in the early 1980s resulted in the flooding of additional agricultural lands near the river and increased costs and delays for navigation interests. In June 1986, the "Fine Tuning Plan" was implemented to address difficulties experienced by navigation interests and farmers as a result of high flows on the system. The objective of the revised operating plan was to provide a different transition from flood releases and increase the number of days where flow was below 80,000 cfs. The new plan included a 75,000 cfs flow bench (*i.e.*, period of time where the flow is held at or below a certain cfs) for 7 to 14 days following flood events. However, problems with sedimentation continue to occur at the 75,000 cfs bench rate, influencing maintenance dredging of the channel.

The 75,000 cfs bench impacts maintenance dredging activities in the lower reaches of the Arkansas River. Dredging is difficult when flows exceed 70,000 cfs and uncontrolled flows during flood events can increase flows to between 85,000 and 90,000 cfs. Therefore, additional delays in the evacuation of the lower portion of the flood control storage are implemented when the system flood storage remaining reaches less than 18 percent. The degree of the delay is dependent on hydrologic conditions, season of the year, and the distribution of the flood control storage within the system.

The "Fine-Tuning Plan" involves five release zones: 1) 150,000 cfs, 2) 150,000 to 135,000 cfs, 3) 75,000 cfs (*i.e.*, the bench), 4) 75,000 to 40,000 cfs, and 5) finally, gradually reducing the target flow at Van Buren from 40,000 cfs to 20,000 cfs when the flood storage in the 11 controlling reservoirs in Oklahoma reaches from 3 percent in the spring to 11 percent in the summer. This plan continued to utilize a 75,000 cfs bench to allow for sediment flush out and to increase the number of days where the flow is held at or below 75,000 cfs to allow dredges to remove flood-induced sedimentation.

CURRENT STUDY AND SPECIFIC PROBLEMS

The purpose of the River Flow Management aspect of the current study is to address various problems, such as flooding, decreased navigation traffic, reduction in hydropower generation, and losses to recreational use along the Arkansas River, influenced by sustained high flows. The study is based upon revisions to the operational flows of the river, as measured at the Van Buren gage. Operational modification of river flows would be accomplished by altering the water storage in the eleven regulating reservoirs.

The objective of the current study is to investigate flow management on the MKARNS to develop solutions that would evacuate high flows through the system at the fastest rate feasible to reduce flood damages, and improve the safety and efficiency of commercial navigation operations while maintaining other project purposes such as recreation, fish and wildlife, water supply, and hydropower. This objective would be achieved by reducing the number of days when river flows exceed 61,000 cfs at the Van Buren gage.

NAVIGATION CHANNEL DEEPENING FEATURE

The proposed Navigation Channel Deepening action would consist of deepening the navigation channel to allow deeper draft tows to operate on the MKARNS. The existing 9-foot navigation channel depth is believed to limit the efficiency and volume of commercial navigation operations on the MKARNS compared to the Lower Mississippi River's authorized 12-foot draft channel. Deepening the channel would remove the disparity between the navigation channel depths of the MKARNS and the Lower Mississippi.

NAVIGATION CHANNEL MAINTENANCE FEATURE

Operation and maintenance of the MKARNS at the existing 9-foot draft channel depth requires periodic dredging at some locations within the navigation system. Some existing authorized dredged material disposal sites have reached capacity and new disposal sites would be required to support continued operation of the existing MKARNS for the 9-foot channel.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The Service's overall planning objective is to conserve important fish and wildlife resources for the benefit of the American people, while facilitating balanced development. This goal is supported by language in the FWCA and other authorities. The FWCA establishes fish and wildlife conservation as a coequal purpose of water resource development projects, and states that fish and wildlife resources shall receive equal consideration with other features of water resource development programs.

Deepening the navigation channel to allow deeper draft tows to operate on the MKARNS and maintaining this navigation channel depth would have significant adverse impacts on both terrestrial and aquatic fish and wildlife resources. In general, these impacts would include the loss of terrestrial habitat due to the disposal of dredged material in upland sites; the loss of aquatic habitat due to disposal of dredged material in aquatic sites and the construction and raising of river training structures; the removal and alteration of gravel bars, which support a variety of aquatic species, due to dredging activity; and adverse effects on freshwater mussel patches and beds (*i.e.,* mussel concentration areas) due to dredging activity and the disposal of dredged material.

The Service has been actively involved with the ARNS over the last several years through participation in numerous site visits, meetings and conference calls pertaining to planning efforts designed to avoid and minimize unnecessary impacts, as well as meetings pertaining to impact assessment analysis and development of appropriate mitigation measures. The Service believes that a complete and thorough analysis for unavoidable project impacts on fish and wildlife resources is necessary to ensure that all losses are adequately and appropriately offset over the project life. Specifically, we believe that a mitigation plan addressing both aquatic and terrestrial resource impacts, developed through interagency coordination, will be necessary to minimize, avoid, and fully compensate for project related impacts.

The Service and our state resource partners have expressed our concern, through the various stages of the study, that the project had been placed on an extremely expedited time schedule, and that, due to the expedited schedule, an adequate assessment of the proposed project's environmental impacts not be possible within the time frame allotted. A more traditional schedule would allow a more thorough evaluation of the project so that full evaluation of all direct, indirect, and cumulative impacts could occur.

Due to the expedited time schedule for the project, the aquatic field studies conducted to describe baseline conditions and evaluate impacts of channel deepening on riverine habitats and associated fish communities throughout the entire 445-mile navigation system was limited to the summer of 2004. Similarly, the study to assess impacts to freshwater mussels was limited in time and scope such that all potential dredging and dredged material disposal areas were not surveyed. While considerable effort has been expended to estimate the overall impact of project implementation, an accurate assessment was impossible due to a lack of detailed baseline information.

The Service alerted the Corps early in project planning stages that the effects of the proposed modifications combined with the continued operation and maintenance of the navigation system on the fish and wildlife resources in the study area (including the reservoirs, wildlife management areas, the downstream segments of the rivers, dike fields, oxbows, and other backwater areas, and the main stem of the navigation channel), likely will have long-term consequences that cannot be adequately identified or appropriately assessed without long-term studies and extensive monitoring efforts. We believe that a long-term adaptive monitoring program developed and implemented through interagency coordination is necessary to fully assess the true magnitude of the cumulative impacts from the proposed modifications, ongoing project maintenance and continued system operation. The program also should identify and address any unmet mitigation needs not anticipated due to the expedited study schedule and lack of detailed information.

EVALUATION METHODS

RIVER FLOW MANAGEMENT FEATURE

The effects of the River Flow Management Action components were evaluated using the Corps "Southwestern Division Modeling System for the Simulation of the Regulation of a Multipurpose Reservoir System," also known as the SUPER Model. The model consists of linked programs designed to "perform" and analyze a period of record for a specific system of reservoirs operated under various plans of regulation. For this study, reservoir elevations and river stages were modeled using 61 years (January 1940 – December 2000) of flow data. This period was considered a good representation of what may be expected in the Arkansas River Basin, because it contains floods with large volumes and high peak flow periods (1943, 1957, 1986, 1990, 1994, and 1995) and drought years (1950's and 1970's).

The following components were examined in detail:

1) No Action Plan (to establish a baseline condition for comparison with the other simulations),

2) the 175,000 cfs Plan: increasing the operating target at Van Buren to 175,000 cfs with a 60,000 cfs bench replacing the 75,000 cfs bench lowered 3 percent (*i.e.*, from 18 to 15 percent system full) except from June 15– October 1.

3) the 200,000 cfs Plan: operating Van Buren at 200,000 cfs with a 60,000 cfs bench replacing the 75,000 cfs bench lowered 3 percent except from June 15 – October 1.

4) the Operations Only Plan: maintaining the existing operating plan (*i.e.*, operating Van Buren at 150,000 cfs), but replacing the current 75,000 cfs bench with a 60,000 cfs bench beginning at 3 percent lower system storage except from June 15 – October 1.

Information obtained from the SUPER Model for each non-structural alternative included 1) average annual river flow and condition, 2) average annual reservoir stages and duration, and 3) operational damages within the system. This analysis was based on average reservoir elevations and river flows over the above period of record.

We determined, using data obtained through the SUPER Model analysis, possible impacts to fish and wildlife resources resulting from the four non-structural operating alternatives selected by the Corps for detailed analysis. For our analysis, we compared future habitat conditions without the project to future habitat conditions with the project conditions for each alternative. Detailed information associated with the SUPER Model screening runs can be found in Appendix A, Hydrology and Hydraulics Report, of the Corp's draft Integrated Feasibility Report (USACE, 2005b).

The Operations Only plan was selected by the Corps as the component of the River Flow Management feature. We then compared daily reservoir elevations under with and without project conditions over the period of record for the Operations Only component at four of the 11 modifying reservoirs on the navigation system: Oologah, Tenkiller, Eufaula, and Keystone. These reservoirs exhibited the greatest change in the number of days they would be expected to be above conservation pool compared to existing conditions, as indicated by the average reservoir pool elevation over the period of record. This analysis allowed us to conservatively evaluate the effects of flow management operations on reservoir elevations under extreme conditions. These extreme conditions, in any given year or during successive years, potentially would have the most significant effect on fish and wildlife resources. Such effects likely would not be apparent from an analysis that examined only averages of reservoir elevations and river flows over the 60-year period of record.

NAVIGATION CHANNEL DEEPENING FEATURE

Early in the evaluation process, a Multi-agency Ecosystem Evaluation Team was established to evaluate impacts of the proposed Navigation Channel Deepening feature on terrestrial and aquatic habitats and ecological benefits resulting from proposed mitigation measures. The multidisciplinary team included biologists with technical expertise from the Little Rock and Tulsa District Corps, the Service, the Corps Engineer Research and Design Center-Environmental Laboratory (ERDC-EL), ODWC, AGFC, and Parsons, a private consulting firm (Table 2). The team evaluated the environmental impacts of proposed dredging and disposal of dredged material using the Habitat Evaluation Procedures (HEP).

Table 2. Interagency Evaluation Team.

Name	**Agency/Company**
Johnny McLean	Corps, Little Rock District
Tony Hill	Corps, Little Rock District
Sandra Stiles	Corps, Tulsa District
Wesley Fowler	Corps, Tulsa District
Charles Schrodt	Corps, Tulsa District
Antisa Webb	ERDC-EL
Kelly Burks	ERDC-EL
Jack Killgore	ERDC-EL
Catherine Murphy	ERDC-EL
Richard Stark	USFWS, Oklahoma Ecological Services
Kevin Stubbs	USFWS, Oklahoma Ecological Services
Lindsey Lewis	USFWS, Arkansas Ecological Services
Marge Harney	USFWS, Arkansas Ecological Services
Gary Peterson	ODWC
Mike Plunkett	ODWC
Randy Hyler	ODWC
Jeff Quinn	AGFC
Stephen Webber	ODEQ
Richard Hall	Parsons

Table 2 Continued

Table 2 Continued

Name	Agency/Company
Randy Norris	Parsons
Virginia Flynn	Parsons
Enid McNutt	Parsons
Luke Eggering	Parsons

Terrestrial Impacts From Dredged Material Disposal

A modified version of the Service's HEP was used to assess impacts at terrestrial dredged material disposal sites and to determine appropriate mitigation measures. Experienced biologists and staff from ERDC, both Corps Districts, the Service's Oklahoma Field Office, and the ODWC jointly developed three wildlife community based models encompassing the major cover types present at proposed dredged material disposal sites in Oklahoma and at proposed mitigation sites. Major cover types consisted of grassland (open field and old field), forest (bottomland hardwood and floodplain forest), and marsh.

Data used in the analysis were collected at representative dredged material disposal sites and at reference sites for each cover type. Data collected from the field investigations at the reference sites also were used to adjust optimum habitat values for each variable within the three models. Data collected at representative dredged material disposal sites were extrapolated to all other disposal sites so that impacts could be predicted. The team of biologists used best professional judgment to project natural succession at selected target years for the dredge disposal sites.

The ERDC-EL used the HEP models and data provided by the interagency team to evaluate impacts from dredged material disposal and determine mitigation needs. The analysis provided a measure of the habitat value of the proposed impact sites and mitigation sites over the 50-year life of the project using a software package developed by the ERDC Environmental Laboratory known as EXHEP *(i.e.,* EXpert Habitat Evaluation Procedure). Impacts were quantified in non-monetary terms using HEP, and provided a basis for determining the measures needed to mitigate for terrestrial dredged material disposal impacts along the system in Oklahoma.

The evaluation rated the quality of each cover type in the project area on a scale of 0.0 to 1.0. The rating (Habitat Suitability Index – HSI) is based on the habitat's capability to support and sustain a community of wildlife, as determined through the evaluation models and the professional judgment of experienced biologists. Cover types with the highest HSI value have the best capability to sustain associated fish and wildlife populations and communities. Multiplying the HSI (quality) by the extent (*e.g.*, acres) of each cover type provides a measure of the Habitat Units (HUs), the combined quality and quantity of habitat.

The average number of HUs expected to be lost or gained annually for each cover type over the 50 year project life provides the average annualized habitat units (AAHUs). The AAHUs were determined for the with and without project conditions to compare future habitat conditions without the project to future habitat conditions with the project. The AAHUs also were determined for proposed mitigation sites. Preliminary discussion, including locations of

mitigation sites, developed in cooperation with the ODWC, was provided in a planning assistance letter from the Service dated June 15, 2004.

The net loss or gain in AAHUs with the project was determined by calculating the difference between annualized loss or gain for the with and without project conditions. The AAHUs at the proposed terrestrial dredged material disposal sites and at the potential mitigation sites were then used to develop a mitigation plan that would completely offset losses of habitat value.

Trade-off rules were developed to ensure appropriate in- and out-of kind mitigation would occur for unavoidable impacts at terrestrial dredged material disposal sites (Table 3). Baseline habitat value (HSI) for agricultural fields managed as food plots for wildlife was assumed to be 0.24 due to the low value provided to evaluation species.

Table 3. Trade-off rules for compensatory mitigation of unavoidable impacts of terrestrial dredge disposal.

Impacted Habitat	**Replacement Habitat**				
	Bottomland Hardwood	**Floodplain Forest**	**Old Field**	**Open Field**	**Marsh Wetland**
Bottomland Hardwood	Yes	No	No	No	No
Flood Plain Forest	Yes	No	No	No	No
Old Field	Yes	No	No	No	Yes
Open Field	Yes	No	No	No	Yes

The following assumptions were made:

- All terrestrial disposal areas would be continuously disturbed and have no fish and wildlife value;
- Under the without project scenario, all mitigation sites remain the same cover type and quality over time;
- Proposed bottomland hardwood and marsh wetland mitigation sites would have restored hydrology and would be maintained over the project life to facilitate attainment of ecological function;
- Bottomland hardwood mitigation sites were considered newly created marsh habitat from the time they were flooded until bottomland hardwood forest would be expected to develop (at project year 11);
- Agricultural land used as food plots would have a low HSI value of 0.24 throughout the 50-year project life;

- Agricultural land not used as food plots were selected for terrestrial disposal sites as a measure to avoid areas that provide quality habitat. These areas were assumed to have no habitat value; and

- All sites selected for compensatory mitigation would currently be agricultural cropland not used as food plots;

Complete details pertaining to the HEP analysis used in this study, including methodology, techniques, graphs and descriptions of the variables assessed for each cover type, cover type acres, HUs, HSI values, and AAHUs, etc., can be found in Appendix C of the Corp's draft Environmental Impact Statement for ARNS (USACOE, 2005a).

Aquatic Impacts: Riverine Habitats And Associated Fish Community

An aquatic field study was conducted by experienced ERDC aquatic biologists to describe baseline conditions and evaluate impacts of channel deepening on riverine habitats and associated fish communities. Due to the expedited time schedule for the project, field data collection was limited to the summer of 2004.

The interagency evaluation team provided input on evaluation procedures through several interagency meetings. The objective of the aquatic evaluation was to provide the greatest amount of information to describe baseline conditions, predict potential impacts, and develop mitigation requirements, all within the allotted time period. Specifically, the objectives of the evaluation were to 1) describe and quantify fish communities and aquatic habitat of representative pools in the MKARNS; 2) quantify amount and location of gravel bars (gravel bars provide spawning habitat for inter-jurisdictional fishes such as paddlefish and shovelnose sturgeon and habitat for many species of aquatic insects, snails, crustaceans, and freshwater mussels) that could be impacted by dredging; 3) quantify relative fishery habitat value of dike fields and other aquatic sites proposed to be used as dredged material disposal sites; and 4) determine appropriate mitigation measures to offset losses in habitat value (Killgore *et al*., 2005).

The representative pools selected for fish and habitat sampling were: 1) pool 2 and the old channel (representing the lower Delta reaches within the Gulf Coastal Plain); 2) pools 5, 6, and 7 (representing the Ouachita Mountains reaches); 3) pools 9, 10, 11, and 12 (representing the Arkansas River Valley reaches between the Ozark and Ouachita Mountains); and 4) pools 16 and 17 (representing the uppermost reaches of the navigation system).

Sampling occurred during April and May 2004. A minimum of three sections was sampled in most pools in order to collect data from the upper, middle, and lower reaches of each pool. Several sites within each section were sampled to incorporate major habitat features (*e.g*., tributary mouths, main channel, and backwater habitats), areas frequently dredged for maintenance purposes, and dredged material disposal sites (Table 4).

Table 4. Fish Sampling Sites in Summer 2004 for the Arkansas River Navigation Project (from Killgore *et al*., 2005)

Site #	Location/Pool	Station	River Mile	Seine	Shock	Trawl
1	Chouteau	Below Newt Graham L&D 18	420.8	√	√	√
2	Chouteau	Channel near Afton Landing	411.0			√
2.5	Chouteau - bw	Afton Landing backwater	BW	√	√	
3	Chouteau	Above Chouteau L&D 17	402			√
4	Chouteau - bw	Backwater at RM 403.2	BW	√		
5	Pool 16	Below Chouteau L&D 17	401.2		√	√
6	Pool 16 - bw	Falls Park Backwater at RM 398	BW		√	
7	Pool 16	Confluence of AR and Verdigris R.	394.5	√	√	√
7.5	Pool 16 - bw	Sandbar Pool at Confluence	394.5	√		
8	Pool 16	Channel at Coody Creek mouth	389.5	√	√	√
8.5	Pool 16 - bw	Backwater at 389.5 (inside sandbar)	BW	√		
9	Pool 16 - trib	Mouth of Coody Creek	389.5		√	
10	Pool 16 - trib	Mouth of Maynard Bayou	387		√	
11	Neosho	Neosho (Grand) River 4 mi. upst. of AR R.	--			√
12	Pool 13	Island above Trimble L&D 13	293.3	√	√	√
13	Pool 13	Right bank upst. of Trimble L&D 13	293.3	√	√	
14	Ozark	Below Trimble L&D 13	289.5	√	√	√
15	Ozark	Channel at mouth of Mulberry River	272	√	√	√
15.5	Ozark	Channel upst. of Mulberry River mouth	277			√
16	Ozark - trib	Lower mouth of Mulberry River	272		√	√
17	Dardanelle	Below Ozark-Jeta L&D 12	256.5	√	√	√
18	Dardanelle	Rock weir at Rogers Cabin	231.5		√	√
19	Dardanelle	Across from Spadra Park	229.8	√	√	√
20	Dardanelle	Mouth of Cabin Creek at ramp nr. old RR bridge	--		√	
21	Pool 9	Below Dardanelle L&D 10	205	√	√	√
22	Pool 7	Below Toad Suck L&D 8 – pool	155.3	√	√	
22.5	Pool 7	Below Toad Suck L&D 8 – channel	155.3	√	√	√
23	Pool 7	Mouth of Fouche La Fave	146.8	√	√	
24	Pool 7	AR @ Fouche La Fave mouth – rt. bank	146.8	√		√
24.5	Pool 7	AR @ Fouche La Fave mouth – lft. bank	146.8	√		
25	Pool 7	2^{o} Channel at Beaver Dam Island	141.5	√	√	√
26	Terry Lake	Below Murray L&D 7 – main channel	124.3	√	√	√
26.5	Terry Lake	Below Murray L&D 7 – side channel	124.3	√		
27	Terry Lake	AR @ downtown Little Rock	120	√	√	
28	Terry Lake - bw	Willow Bend Cutoff nr. Terry L&D 6	108.4		√	
29	Terry Lake	Above David D. Terry L&D 6	109.8	√	√	√
30	Pool 5	Below David D. Terry L&D 6	107.6	√	√	√
31	Pool 2	Below Joe Hardin L&D 3	49.6	√	√	√
32	Pool 2	AR @ Mud Lake entrance	44.6	√		√
32.5	Pool 2 - bw	Inside Mud Lake entrance	44.4	√	√	
33	Pool 2	Upst. of mouth of Big Bayou Meto	31.7	√	√	√
34	Pool 2 - bw	AR @ mouth of Big Bayou Meto	31.2	√	√	
35	Pool 2	Post Canal at Merrisach Lake	14.4	√	√	
36	Pool 2	Above L&D 2	13.4		√	√
37	Wild AR R.	1 mile dnst. of Wilbur D. Mills Dam – channel	--	√	√	√
37.5	Wild AR R.	1 mile dnst. Of Wilbur D. Mills Dam – bw	--	√		
38	Wild AR R.	Below Wilbur D. Mills Dam	--		√	

Multiple sampling gear types were used to collect fishery data from three different aquatic fishery habitats. Seining was employed to collect littoral/shoreline fishes. Electrochocking was used to collect pelagic/slack water fishes. Benthic trawls were used for demersal and main channel fishes (Table 4).

Physical parameters were measured concurrently with fish sampling efforts. Physical parameters recorded include stream width, substrate composition, percent instream cover, water temperature, pH, conductivity, dissolved oxygen, and turbidity. Occurrences of major backwaters adjacent to sampling sites also were recorded.

Multiple regression analysis on seining and electrofishing data was used to identify the influence of project impacts on fish communities. Fish were classified as either pool dwelling/backwater species or gravel associated species. Total number of fish collected at each site was used as the dependent variable. Water depth and amount of gravel were used as the independent variables.

The regression analysis of seining data indicated a positive relationship between fish abundance and the depth of the dike pools and the amount of gravel available. This relationship implies that reducing water depth in a dike field pool and reducing the amount of gravel in the channel would adversely impact pool dwelling and gravel associated fish. Analysis of electrofishing data for pool-dwelling fishes did not provide a significant model. This is likely attributable to the prevalence of pool like habitat throughout the navigation system and the lack of physical habitat variation at the sites sampled needed for the identification of predictive relationships.

An aquatic HEP was developed by the ERDC with input from biologists from the Service, ODWC, AGFC, and the Corps Tulsa and Little Rock Districts (interagency evaluation team). The aquatic HEP was used to assess impacts from the disposal of dredged material and to assess overall potential impacts of the proposed project on aquatic resources. The aquatic HEP also was used to provide a basis for determining the mitigation measures needed to compensate for aquatic impacts. Future with and without the project conditions were predicted to determine habitat value at impact sites and potential mitigation sites over the 50-year life of the project.

The interagency evaluation team evaluated the impacts and benefits that would occur at 185 disposal/mitigation sites in Arkansas and 39 sites in Oklahoma. Existing HSI values at disposal and mitigation sites were determined using best professional judgment of the interagency evaluation team, while examining Red Hen (aerial) video of the navigation system (recorded from August 9 – 13, 2004), from maps, and existing local expertise. HSI values for the with and without out project condition also were predicted for target years 11, 31, and 51. These HSI values for the with and without project conditions then were adjusted downward using an estimated filling coefficient, as explained below.

Dredged material would be placed in dike fields in Arkansas. A filling rate for Arkansas dike field disposal sites was estimated in order to determine the remaining life of the dike fields. The filling rate was calculated based on dredging records from Pools 2, 7, and 12, and averaged over the length of the project.

Corps engineers estimated that complete filling of the dike fields to be used as disposal areas would occur in 117, 79, and 66 years for the 9-, 11-, and 12-foot alternatives, respectively. For example, for the 12-foot alternative, dike fields would be 75 percent full on average at the end of the project life (50/66 = 0.75). Because filling of the dike pools is anticipated to negatively affect habitat quality, as indicated by multiple regression analysis, the estimated annual filling rate was used to reduce the HSI of dike field disposal sites over the life of the project. The value at 25 years was derived from a linear relationship and was used to obtain AAHUs. Sediment accretion in a dike field is extremely variable, but the rate of change was assumed to be linear to simplify the analysis. The adjusted filling rate is called the filling coefficient (Table 5). The without project AAHUs were determined using the filling coefficient for the existing 9-foot channel since maintenance activity would be necessary to maintain the 9-foot channel depth.

Table 5. Conversion of estimated fill rates of dike fields to filling coefficients used to annualize Habitat Suitability Index values over the life of each project alternative (from Killgore *et al*., 2005).

	Maintain 9-ft channel	Dredge 11-ft channel	Dredge 12-ft channel
Fill rate (percent per year)	0.86 percent	1.35 percent	1.63 percent
Time until 100 percent full	117 years	79 years	66 years
Percent full at 50 years	43 percent	63 percent	76 percent
Percent full at 50 years (notched dikes/revetments)	21.5 percent	31.5 percent	38 percent
Percent full at 25 years	**21.5 percent**	**31.5 percent**	**38 percent**
Percent full at 25 years (notched dikes/revetments)	**10.75 percent**	**15.75 percent**	**19 percent**

The interagency evaluation team proposed dike notching as a mitigation measure that would serve to minimize impacts of the channel deepening component at dike fields that would be used as disposal sites, and at those that would not receive dredged material (*e.g*., dike fields in Oklahoma). Notches in dikes would facilitate scouring in the dike pools behind the notch, and thereby increase habitat complexity. Therefore, we assumed that the HSI values of dike fields with notched dikes would decline 50 percent less than that of an un-notched dike field (Table 5).

Three broad types of mitigation measures were proposed by the interagency evaluation team to offset project impacts: 1) Avoid, 2) Minimize, and 3) Compensate. Avoidance measures would consist of avoiding disposal of dredged material at a site estimated to have high habitat quality by relocating the disposal site to a location of lesser habitat value, as determined by best professional judgment of the evaluation team. Minimization projects consisted of features assumed by the team to minimize the impacts of the project. Notching a dike is assumed to minimize impacts to dike field habitat. Compensatory mitigation features consisted of projects that would restore, enhance, or create habitat. Figure 2 provides a flow model describing how benefits were determined under each type of mitigation measure.

Several sources were utilized to preliminarily determine the extent of gravel bars: 1) existing GIS layers of gravel deposits, 2) Red Hen video footage of the navigation system recorded August 9 – 13, 2004, 3) locations of current and historical gravel mining operations, and 4) observations recorded by field crews during fish sampling.

Field observations of gravel bars were conducted when a channel trawl yielded gravel in the sample and during velocity transect measurements. A 16-foot otter trawl with 1-inch mesh was used to sample benthic fishes. Trawls were dragged along the river bottom at 2 – 5 miles per hour for 10 – 20 minute intervals. All occurrences of gravel in the trawl sample were recorded.

Velocity transect measurements were taken at representative cross sections of the channel. A metal weight carrying a velocity meter was lowered to the bottom of the channel. The operator determined the substrate based on the vibration produced by the metal as it hit the river bottom. Substrate was recorded as mud, sand, gravel, bedrock, rip rap, or detritus/woody debris.

GPS coordinates for all potential gravel bar locations were recorded. Potential gravel bed locations were incorporated as a layer in a GIS database. GIS maps were used to examine potential gravel sites for features that influence substrate composition. The features examined were channel width, channel morphology, channel depth, scour, adjacent bars, dike fields, and size of nearby tributaries. The potential proportion of gravel substrate at a site was estimated based on the width of the channel. The potential proportion of gravel for each site was then multiplied by the site area to obtain an estimate of the amount of gravel.

Potential gravel bed locations were compared to the GIS layer of proposed dredging locations to obtain an estimate of project impacts on gravel beds. The potential locations of gravel bars that could be impacted were visited by a hydrographic survey crew from the Corps Memphis District to further examine and map locations of the gravel substrates. The crew used a sounding chain to identify the predominant substrates at the potential gravel bar locations as sand, sand/gravel mix, or pure gravel. The survey boat moved slowly down longitudinal transects within the GIS dredge polygon (*i.e.*, area proposed to be dredged) while dragging the sounding chain along the river bottom. Each substrate type was digitally recorded. The maps were incorporated into the project GIS to determine the estimated acres by pool of sand/gravel mix and pure gravel.

The interagency evaluation team agreed that the goal of mitigation for impacts to pure gravel bars should be no-net-loss when possible. This habitat is a finite resource in the navigation system and is of great importance as a habitat feature for a variety of sensitive fishes such as paddlefish and sturgeon.

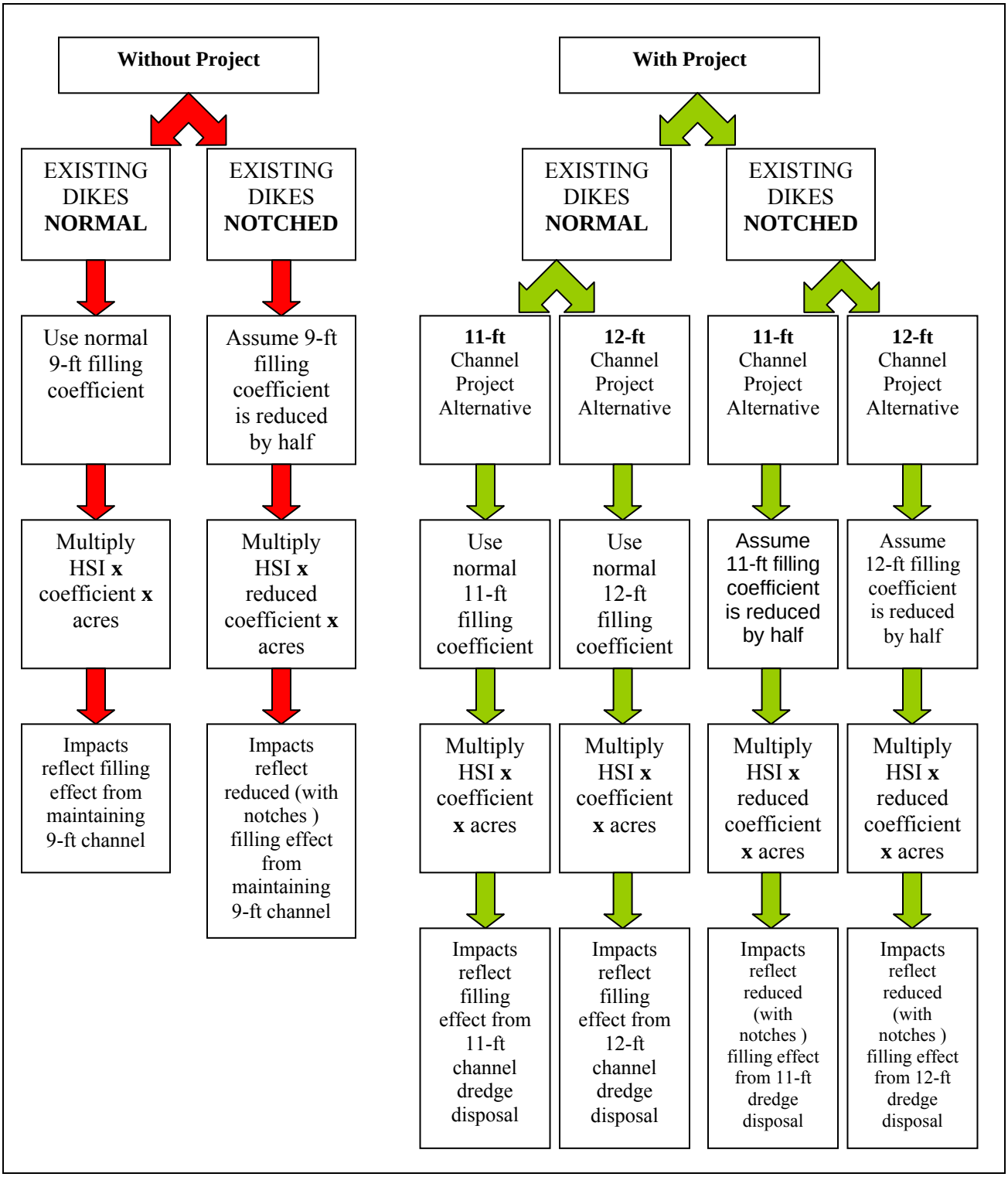

Figure 2. Conceptual model used to calculate project impacts by alternative (from Killgore *et al.*, 2005).

Aquatic Impacts: Freshwater Mussels

A freshwater mussel (unionid) distribution study from the Port of Catoosa, Oklahoma, to the navigation system's confluence with the Mississippi River in Arkansas was conducted during the summer and fall of 2004 by Ecological Specialists, Inc. This study provides unionid species composition and distribution data throughout the MKARNS (Ecological Specialists, 2005). The study was used to assess potential impacts to freshwater unionids and develop mitigation measures to avoid and minimize adverse impacts. Sampling efforts focused on areas proposed to be dredged and on open water dredged material disposal sites. Sampling sites were selected during an interagency meeting among the Corps, Service, and the AGFC.

Sediment Quality Analysis

A screening level analysis of MKARNS sediment quality was performed during September 2004 for both future maintenance dredging needs for the 9-foot channel and for impact assessment for the proposed channel deepening component. The analysis was necessary to determine the types and locations of expected contaminants in dredged sediment, and to develop disposal measures necessary to minimize the environmental impact of disposal of contaminated sediments, if necessary. Detailed information regarding sampling site selection, sampling methods, analytical parameters, threshold values for data interpretation, constituents selected for analysis, and the chemical methods employed can be found in Appendix E of the DEIS for ARNS (USACOE, 2005a).

NAVIGATION CHANNEL MAINTENANCE FEATURE

Impacts anticipated as a result of the Navigation Channel Maintenance feature were assessed using the same methodology as described above for the Navigation Channel Deepening feature.

FISH AND WILDLIFE RESOURCES: EXISTING

This section provides information on the terrestrial and aquatic fish and wildlife resources associated with the MKARNS, the 11 Oklahoma reservoirs and their associated rivers/streams, wildlife management areas, and national wildlife refuges. This section also provides information on federally-listed threatened and endangered species as well as species proposed for listing, species of concern, and state-listed and rare species that occur within the vicinity of the project area. Detailed descriptions of the existing aquatic and terrestrial resources of the individual reservoirs and associated streams/rivers have been provided in previous reports on various individual projects (lock and dams, hydropower, etc.) and will not be repeated here.

ARKANSAS/VERDIGRIS RIVERS AND 11 OKLAHOMA RESERVOIRS: AQUATIC AND WETLAND RESOURCES

Aquatic cover types in the project include lentic habitats (reservoirs and ponds), lotic habitats (rivers and streams) and wetlands. These habitat types support numerous game and nongame fish and wildlife species. A list of indicator flora and fauna for both aquatic and terrestrial habitat types is presented in Table 6.

Fishery Resource

A variety of fish species occur in the project area. Prior to construction of the locks, dams, and reservoirs on the MKARNS, the fish fauna in the various rivers/streams were diverse and unique. However, construction and operation of the MKARNS has altered the magnitude and frequency of flow events, stabilized channel conditions, and created reservoirs that provide habitat for lake fishes, but limit habitat for native riverine species. The overall result is a more homogenous aquatic environment within the MKARNS that benefits particular fish fauna to the detriment of others (Buchanan, 1976). Thus, fishery resources are generally uniform throughout the MKARNS, except in areas where trout are stocked downstream of reservoirs with cold water discharges, such as in the lower Illinois River below Tenkiller Ferry.

Eighty-six fish species are known to occur in the navigation system in Oklahoma. About 108 species are reported from the system in Arkansas (Buchanan, 1976; Limbird, 1993). A list of fish species common to the 11 upstream reservoirs in Oklahoma is provided in Table 7. Table 8 lists fish species known to occur in the MKARNS in Oklahoma and Arkansas.

Killgore *et al*. (2005) collected 65 fish species during the fish sampling effort conducted for this study. This drop in species diversity as compared to previous studies (*e.g*., Buchanan, 1976) is likely attributable to the relatively limited survey effort conducted by Killgore *et al*. (2005). The limited survey effort was due to time limitations caused by the expedited project schedule. The previous surveys were conducted over a greater period of time (*e.g*., 7-month period in Buchanan (1976) versus a 2-month period in 2004), consisted of a greater number of collections (75 seine samples in 1976 vs 33 seine samples in 2004), used disparate techniques (rotenone in 1976, trawling in 2004), and included habitats outside the current project area (clear tributaries). Most of the 45 species reported in 1976, but not collected in 2004, were rare (represented by 5 or fewer specimens). Gizzard and threadfin shad were the most abundant species in both the 1976 and 2004 surveys.

Table 6. Cover types, indicator species, and cover type value – index. Indices range from 1 (low habitat potential) to 5 (high habitat potential) (modified from U. S. Fish and Wildlife Service, 1985).

Cover Type	Indicator Flora	Indicator Fauna	Cover Type Value-Index
Post oak-blackjack oak forest	post oak, blackjack oak, dogwood, red cedar, sumacs, buckbrush	white-tailed deer, fox squirrel, bobwhite, carolina chickadee, black and white warbler, armadillo, garter snake, ground skink	3
Oak-hickory forest	post oak, black hickory, mockernut hickory, bitternut hickory, white oak, sugar maple, winged elm	white-tailed deer, fox squirrel, gray squirrel, eastern woodrat, cottontail rabbit, eastern chipmunk, downy woodpecker, white-breasted nuthatch, fence lizard, black rat snake, American toad	4
Oak-hickory-pine forest	post oak, white oak, northern red oak, mockernut hickory, bitternut hickory, black hickory, shagbark hickory, shortleaf pine, loblolly pine, sweetgum	white-tailed deer, fox squirrel, pileated and hairy woodpeckers, gray fox, three-toed box turtle	4
Tallgrass prairie	big and little bluestem, switch grass, Indian grass, goldenrods, side oats grama	coyote, red-tailed hawk, bobwhite, eastern meadowlark, grasshopper sparrow, dickcissel, ornate box turtle, ribbon snake, great plains rat snake	3

Table 6 continued

Cover Type	Indicator Flora	Indicator Fauna	Cover Type Value-Index
Mixed-grass prairie	little and big bluestem, purple cone flower, gramas, buffalo grass	thirteen-lined ground squirrel, eastern cottontail, jackrabbit, bobwhite, ornate box turtle, Texas horned lizard, prairie kingsnake, prairie skink, Woodhouse's toad	3
Caves	–	Bats (*Myotis* and *Pipistrellus* spp.), Ozark cavefish, grotto salamander, cave salamander	5
Cropland	wheat, alfalfa, soybeans, sorghums, etc	white-footed mouse, eastern cottontail, mourning dove, eastern meadowlark	2
Introduced grassland	Bermuda grass, fescue, rye, buffalo bur, nightshade, ragweeds	cotton rat, eastern meadowlark	1
Riparian forest	cottonwood, willow, green ash, hackberry, elm, sycamore, dogwood, river birch	white-tailed deer, raccoon, river otter, beaver, red-bellied woodpecker, belted kingfisher, eastern phoebe, fox squirrel, wood duck, herons, cricket frog, green frog	5

Table 6 continued

Cover Type	Indicator Flora	Indicator Fauna	Cover Type Value-Index
Bottomland forest	oaks, sycamore, elms, pecan, boxelder, greenbriar	white-tailed deer, gray squirrel, pileated woodpecker, wood duck, red-shouldered hawks, spring peeper	5
Mud flats	devoid of vegetation when inundated; barnyard grass, rushes, sedges.	raccoon, lesser yellowlegs, common snipe, great blue heron	2 – 5
Lower hardwood swamp forests	red maple, water hickory, green ash, river birch, hackberry, American holly, sweetgum, willow oak, laurel oak	white-tailed deer, beaver, ducks, warblers, herons, egrets, prothonotary warbler, squirrel, swamp rabbit, spotted salamander, chorus frogs, aquatic snakes	5
Lacustrine fringe wetland	cattails, rushes, smartweeds, muskgrass, sedges	bullfrog, cricket frog, carp, water snakes, belted kingfisher, great blue heron, ducks	4
Palustrine pond wetland	willows, cottonwood, cattails, rushes, pondweed, sedges, buttonbush	beaver, great blue heron, egrets, American bittern, waterfowl, snipe, marsh hawk, marsh wren, red-winged blackbird, grebes, leopard frog, eastern newt	5

Table 6 continued

Cover Type	Indicator Flora	Indicator Fauna	Cover Type Value-Index
Lentic aquatic habitat	algae, coontail, bladderwort	largemouth bass, bluegill, catfish, crappie, carp	4
Lotic aquatic habitat	algae, other periphyton	minnows, sauger, bass, channel catfish, sturgeon	3 – 5*

* mountain streams = 5; Arkansas River/System and associated tributaries and delta streams = 3.

Table 7. Common fish species found in the 11 Oklahoma reservoirs.

	Copan	Hulah	Oologah	Kaw	Keystone	Grand	Hudson	Fort Gibson	Tenkiller	Eufaula	Wister
Species											
largemouth bass	X	X	X	X	X	X	X	X	X	X	X
spotted bass						X	X	X	X		
smallmouth bass			X			X	X		X	X	
white crappie	X	X	X	X	X	X	X	X	X	X	
black crappie			X		X		X		X		
white bass		X	X		X	X	X	X	X	X	X
striped bass	X/hybid		X/hybrid	X	X	X/hybrid	X		X		
channel catfish	X	X	X	X	X	X		X	X	X	
bluegill	X	X	X	X	X	X	X	X	X	X	X
longear sunfish	X	X	x		X	X	X	X	X	X	
carp		X	X		X	X	X	X	X	X	X
freshwater drum		X	X		X	X	X	X	X	X	
smallmouth buffalo		X			X	X	X	X	X	X	X
bigmouth buffalo		X	X				X	X	X	X	X
river carpsucker		X	X		X	X		X	X	X	
black bullhead								X	X		
spotted sucker									X		
golden redhorse									X	X	

Table 7 continued

	Copan	Hulah	Oologah	Kaw	Keystone	Grand	Hudson	Fort Gibson	Tenkiller	Eufaula	Wister
river redhorse									X	X	
shorthead redhorse									X	X	
flathead catfish	X	X	X	X	X	X	X	X	X	X	X
longnose gar		X							X	X	
spotted gar		X							X	X	
gizzard shad		X	X	X	X	X	X	X	X	X	
walleye			X				X	X	X	X	
paddlefish			X	X		X	X	X			
black bullhead		X			X						
green sunfish		X	X		X	X	X	X	X	X	
warmouth			X		X	X	X	X	X	X	X
orange spotted sunfish		X	X		X		X	X			X
redear sunfish		X	X	X	X	X	X	X	X	X	X

Table 8. Partial listing of fish species known to occur in the MCKARNS and tributaries in Oklahoma and Arkansas (Buchanan, 1976; Jimmie Pigg, unpublished data).

Common Name	Scientific Name
Chestnut lamprey	*Ichthyomyzon castaneus*
Bowfin	*Amia calva*
American eel	*Anguilla rostrata*
blue catfish	*Ictalurus furcatus*
channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictus olivaris*
yellow bullhead	*Ictalurus natalis*
black bullhead	*Ictalurus melas*
tadpole madtom	*Notorus gyrinus*
brindled madtom	*Notorus miurus*
White bass	*Morone chrysops*
striped bass	*Morone saxatilis*
largemouth bass	*Micropterus salmoides*
spotted bass	*Micropterus punctulatus*
black crappie	*Pomoxis nigromaculatus*
white crappie	*Pomoxis annularis*
walleye	*Stizostedion vitreum*
sauger	*Stizostedion canadense*
warmouth	*Lepomis gulosus*
green sunfish	*Lepomis cyanellus*
longear sunfish	*Lepomis megalotis*
luegill	*Lepomis macrochirus*
orangespotted sunfish	*Lepomis humilis*
longnose gar	*Lepisosteus osseus*
spotted gar	*Lepisosteus oculatus*
shortnose gar	*Lepisosteus platostomus*

Table 8 continued

Common Name	Scientific Name
skipjack herring	*Alosa chrysochloris*
shovelnose sturgeon	*Scaphirhynchus platorynchus*
paddlefish	*Polyodon spathula*
blue sucker	*Cycleptus elongatus*
largemouth buffalo	*Ictiobus cyrpinellus*
smallmouth buffalo	*Ictiobus bubalus*
river carpsucker	*Carpiodes carpio*
golden redhorse	*Moxostoma erythrurum*
common carp	*Cyprinus carpio*
freshwater drum	*Aplodinotus grunniens*
gizzard shad	*Dorosoma cepedianum*
threadfin shad	*Dorosoma pentenense*
golden shiner	*Notemigonus crysoleucas*
pallid shiner	*Hybopsis amnis*
redfin shiner	*Lythrurus umbratilis*
emerald shiner	*Notropis atherinoides*
ghost shiner	*Notropis buchanani*
mimic shiner	*Notropis volucellus*
central stoneroller	*Campostoma anomalum*
blackstripe topminnow	*Fundulus notatus*
blackspotted topminnow	*Fundulus olivaceous*
bullhead minnow	*Pimephales vigilax*
suckermouth minnow	*Phenacobius mirabilis*
silver chub	*Macrhybopsis storeriana*
mosquito fish	*Gambusia affinis*
brook silversides	*Labidesthes sicculus*
logperch	*Percina caprodes*
greenside darter	*Etheostoma blennioides*
bluntnose dater	*Etheostoma chlorosomum*
fantail darter	*Etheostoma flabellare*
slough darter	*Etheostoma gracile*
cypress darter	*Etheostoma proeliare*
banded darter	*Etheostoma zonale*
dusky darter	*Percina sciera*
redfin darter	*Etheostoma whipplei*

Electrofishing was conducted in numerous habitats, and allowed for fish species diversity comparisons among the different habitats. Killgore *et al*. (2005) found that dike fields, armored

banks, sand bars, and wooded banks yielded high species diversity (> 30 spp.). Fish species diversity was found to be moderate in impoundments, aquatic vegetation, and rock outcroppings (20 - 26 spp.). Sampling in the main channel and along eroded banks yielded the lowest species diversity (< 10 spp.).

However, sampling effort was variable among habitats. The number of observed species collected from each habitat, therefore, could not be directly compared or used to assess the ecological value of the habitat. Killgore *et al*. (2005) used rarefaction (*i.e.,* a statistical method used to compare the number of taxa from samples of different size; Ludwig and Reynolds, 1988; Holland, 2003) to compensate for the uneven sampling efforts. Rarefaction was used to estimate the number of species expected to occur in a sample of 25 randomly drawn individuals from a single habitat. This analysis indicated that dike fields and sand bars are the most species rich habitats (>11 spp./25). Impoundments, rock outcroppings, wooded or armored banks also were identified as species rich (about 10 spp./25). The main channel and along eroded banks were identified as the lowest in species diversity (5 – 7 spp./25). The rarefaction analysis yielded similar species diversity as the electrofishing results.

Management of the fishery resources in the project area is a cooperative effort between the Corps and the respective state wildlife agencies, and involves monitoring studies and stocking programs. Management programs influence all species, but concentrate on those most popular with anglers, such as largemouth bass, crappie, walleye, blue catfish, flathead catfish, white bass, and striped bass.

Commercial fishing within the MKARNS is limited to Arkansas, where commercial fishing has occurred since 1971. Commercial fish include catfish, smallmouth buffalo, drum, carp, gar, carpsucker, bowfin, and paddlefish.

Paddlefish, considered imperiled in both Oklahoma (Natural Heritage S1S2 ranking) and Arkansas (S2), were once common in big rivers in the Mississippi Basin, such as the Arkansas River. Excessive commercial harvest for roe (mass of eggs in the female fish) that is processed and sold as caviar, and water development projects that greatly altered their natural habitat have drastically reduced paddlefish populations in the Arkansas River.

Paddlefish are smooth-skinned fish with an elongated snout that occupy the calmer, open waters of large rivers. They prefer slow moving water behind islands and sandbars because of the abundance of zooplankton, their primary food source. Spawning occurs in mid channel currents over gravel substrates where adhesive eggs stick until hatching. Rising water levels in spring trigger upstream spawning migrations. However, in many cases, migrations are blocked by dams. In addition, dredging, flow alterations, and channelization have reduced the available habitat for spawning.

Restoration attempts through a joint effort of the Tishomingo National Fish Hatchery, Oklahoma Fisheries Resource Office, Oklahoma Ecological Services, and the ODWC have resulted in a self-sustaining population above Kaw Reservoir in Oklahoma, and the stocking of about 80,000 paddlefish in the Arkansas and Verdigris rivers in northeastern Oklahoma. The population in the

Verdigris River also is considered stable and self-sustaining. Currently, Service fisheries biologists are conducting surveys on the brood stock in the Arkansas and Verdigris rivers.

Other aquatic resources of significance include oxbow lakes (old river and stream channels that have been cut off from the main channel) adjacent the MKARNS, tributaries of the MKARNS in Arkansas (mountain streams west of Little Rock and delta streams east of Little Rock (Table 9)). Prominent game species inhabiting the oxbow lakes include largemouth bass, catfish, bluegill, and crappie. The fisheries of the mountain streams in Arkansas are considered excellent for smallmouth bass, largemouth bass, spotted bass, bluegill, and sauger. The principal fish species in the delta streams include crappie, catfish, bluegill, largemouth bass, carp, and buffalo.

Four Corps lakes in Arkansas that total 51,360 surface acres (Blue Mountain Lake on the upper reach of the Petit Jean River, Lake Dardanelle and Ozark Lake on the MKARNS, and Nimrod Lake on the upper reach of the Fourche Lafave River) also provide habitat for some fish species. Common game and commercial fish species occurring in the four Corps lakes in Arkansas include largemouth bass, bluegill, crappie spp., and striped bass (U. S. Fish and Wildlife Service, 1988).

Table 9. Major Tributaries of the Arkansas River in Arkansas (U. S. Fish and Wildlife Service, 1988).

Mountain Steams	Delta Streams
Little Maumelle River	Big Bayou Meto
Maumelle River	Little Bayou Meto
Palarm Creek	Plum Bayou
Cadron Creek	Pennington Bayou
Point Remove Creek	
Illinois Bayou	
Spadra Creek	
Big Piney Creek	
Lee Creek	
Petit Jean River	
Fourche Lafave River	
Mulberry River	

Mussel Fauna

Fifty-five species of unionids have been reported to historically occur in the Arkansas River. Thirty-seven of these species were reported from Arkansas, while 49 were reported from Oklahoma (Table 10; Ecological Specialists, 2005). Thirty species were common to both states.

Information on freshwater mussel species (unionids) composition and distribution for the main stem of the MKARNS is limited to a few studies (Isley, 1925 for the Verdigris River; Davison,

1997 for work in Dardanelle and Ozark pools; and Harris, 1992 for a study in Dardanelle pool). Due to limited existing information, a study was conducted during 2004 by Ecological Specialists, Inc. (O'Fallon, Missouri) to determine 1) unionid distribution and composition in the MKARNS, and 2) how the navigation channel deepening component of the proposed project would affect unionids. Sampling areas focused on proposed dredge and dredged material disposal sites (Ecological Specialists, 2005).

Table 10. Mussel species historically recorded from the Arkansas River drainage (from Ecological Specialists, 2005).

Species[1]	AR[2]	OK[3]
Actinonaias ligamentina	x	x
Alasmidonta marginata	x	x
Amblema plicata	x	x
Anodonta suborbiculata	x	-
Arcidens confragosus	x	x
Cyprogenia aberti (OK II)	x	x
Ellipsaria lineolata	x	x
Elliptio complanata	-	x
Elliptio dilatata	x	x
Fusconaia ebena	x	-
Fusconaia flava	x	x
Lampsilis abrupta (FE)	x	-
Lampsilis cardium	x	x
Lampsilis hydiana	x	x
Lampsilis powelli (FE)	-	x
Lampsilis rafinesqueana (FC)	-	x
Lampsilis satura	-	-
Lampsilis siliquoidea	x	x
Lampsilis teres	x	x
Lasmigona complanata	x	x
Lasmigona costata	x	x
Leptodea fragilis	x	x
Ligumia recta	x	x
Ligumia subrostrata	-	x
Megalonaias nervosa	x	x
Obliquaria reflexa	x	x
Obovaria jacksoniana	x	x
Obovaria olivaria	x	-
Plectomerus dombeyanus	x	-
Pleurobema cordatum	x	x
Pleurobema rubrum	-	x
Pleurobema sintoxia	-	x

Table 10 continued.

Species[1]	AR[2]	OK[3]
Potamilus alatus	-	x
Potamilus capax (FE)	-	?
Potamilus ohiensis	x	x
Potamilus purpuratus	x	x
Ptychobranchus occidentalis	-	x
Pyganodon grandis	x	x
Quadrula cylindrica (OK II)	x	x
Quadrula nobilis (aspera)	-	x
Quadrula metanevra	x	x
Quadrula nodulata	x	x
Quadrula p. pustulosa	x	x
Quadrula quadrula	x	x
Strophitus undulates	-	x
Toxolasma lividus	-	x
Toxolasma parvus	-	x
Tritigonia verrucosa	x	x
Truncilla donaciformis	-	x
Truncilla truncate	x	x
Uniomerus tetralasmus	x	x
Utterbackia imbecillis	x	x
Villosa arkansasensis	-	x
Villosa iris	-	x
Villosa lienosa	-	x
Total No. species	37	49

[1]Nomenclature follows Turgeon *et al*. (1998); except *Q. aspera (=nobilis)* follows Watters (OSU, pers. comm. 2004)
FE=federally endangered, FC=federal candidate, OK II=Oklahoma category II
[2]Arkansas (Gordon, 1984-White River site below Newport included; Harris and Gordon, 1986)
[3]Oklahoma (Branson, 1982, 1983, 1984; Shepard and Covich, 1982; Vaughan and Spooner, 1994)

Twenty-seven species were collected during the survey effort (Table 11). No federally-listed threatened or endangered species were found. The largest concentration of mussels was found to occur in the Arkansas Post Canal, where as many as 2,000,000 mussels may occur.

Table 11. Number of unionid species and individuals collected within each MKARNS Reach, 2004 (from Ecological Specialists, 2005).

	Reach 1		Reach 2		Reach 3		Reach 4		Reach 5		Reach 6		Total	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Amblema plicata	541	17.7	-	-	6	0.6	2	0.5	21	2.3	3	1.69	573	10.5
Anodonta suborbiculata	1	0.0	-	-	10	1.1	1	0.3	9	1.0	-	-	21	0.4
Arcidens confragosus	11	0.4	-	-	-	-	5	1.3	4	0.4	-	-	20	0.4
Fusconaia ebena	8	0.3	-	-	-	-	-	-	2	0.2	-	-	10	0.2
Fusconaia flava	1	0.0	-	-	-	-	-	-	8	0.9	-	-	9	0.2
Lampsilis cardium	2	0.1	-	-	-	-	-	-	-	-	-	-	2	0.0
Lampsilis siliquoidea	1	0.0	-	-	-	-	-	-	-	-	-	-	1	0.0
Lampsilis teres	117	3.8	-	-	7	0.8	-	-	1	0.1	1	0.56	126	2.3
Lasmigona c. complanata	2	0.1	-	-	-	-	-	-	WD	-	-	-	2	0.0
Leptodea fragilis	17	0.6	1	5.0	34	3.7	4	1.0	25	2.8	17	9.6	98	1.8
Megalonaias nervosa	119	3.9	-	-	31	3.3	1	0.3	9	1.0	WD	-	160	2.9
Obliquaria reflexa	250	8.2	4	20.0	207	22.3	84	21.6	213	23.6	88	49.7	846	15.5
Obovaria olivaria	5	0.2	-	-	-	-	-	-	-	-	-	-	5	0.1
Plectomerus dombeyanus	909	29.8	-	-	238	25.7	132	34.0	1	0.1	-	-	1280	23.4
Pleurobema cordatum	-	-	-	-	-	-	-	-	-	-	WD	-	WD	-
Potamilus ohiensis	2	0.1	FD	-	29	3.1	2	0.5	37	4.1	9	5.08	79	1.4
Potamilus purpuratus	204	6.7	WD	-	27	2.9	-	-	7	0.8	12	6.78	250	4.6
Pyganodon grandis	50	1.6	1	5.0	50	5.4	19	4.9	31	3.4	WD	-	151	2.8
Quadrula aspera	122	4.0	-	-	28	3.0	15	3.9	26	2.9	-	-	191	3.5
Quadrula nodulata	27	0.9	-	-	-	-	-	-	-	-	8	4.52	35	0.6
Quadrula p. pustulosa	13	0.4	-	-	1	0.1	-	-	12	1.3	15	8.47	41	0.7
Quadrula quadrula	636	20.8	14	70.0	248	26.8	117	30.2	482	53.4	10	5.65	1507	27.6
Strophitus undulates	-	-	-	-	-	-	-	-	1	0.1	-	-	1	0.0
Toxolasma parvus	-	-	-	-	-	-	-	-	1	0.1	-	-	1	0.0
Toxolasma sp.	WD	WD	-	-	-	-	-	-	-	-	-	-	WD	-
Tritogonia verrucosa	*8*	*0.3*	-	-	-	-	-	-	*8*	*0.9*	*14*	*7.91*	*30*	*0.5*
Truncilla donaciformis	1	0.0	-	-	2	0.2	3	0.8	2	0.2	-	-	8	0.1
Truncilla truncate	1	0.0	-	-	1	0.1	1	0.3	-	-	-	-	3	0.1
Utterbackia imbecillis	5	0.2	-	-	8	0.9	2	0.5	2	0.2	-	-	17	0.3
Total	3053		20		927		388		902		177		5467	
No. live species	25		4		16		14		21		10		27	
Total no. species	26		6		16		14		22		13		29	

Note: FD=freshly dead shell, WD=weathered dead shell. Reach 1 = confluence of Mississippi River to Bunge Corporation dock near Pine Bluff, AR (NM 0 – 75.2); Reach 2 = Bunge Corporation Dock to Union pacific railroad Crossing in Little Rock, AR (NM 75.2 – 119.5); Reach 3 = Union Pacific railroad crossing to near Shoal Creek (NM 199.5 – 220.3); Reach 4 = Shoal Creek to near mouth of Poteau River (Nm 220.3 – 308.7); Reach 5 = from near the Oklahoma/Arkansas border to the Verdigris River (NM 308.7 – 394.0); Reach 6 = junction of Grand and Arkansas Rivers to the head of navigation at the Port of Catoosa (NM 394 -445).

Based on their sampling efforts, Ecological Specialists (2005) concluded that 1) the MKARNS provides limited habitat for mussels, 2) the navigation system does not support a significant unionid community, and 3) that the species that occurred in the river were common. The mussel study report provides details on methodology, sampling sites, and results, and can be found in Appendix C of the DEIS for the Arkansas River Navigation Study (USACOE, 2005a).

Commercial harvesting of freshwater mussels also occurs on the navigation system, primarily from the Arkansas River in Arkansas. Ft. Gibson Reservoir on the Grand River undergoes most of the relatively limited shelling that occurs in Oklahoma (Limbird, 1993).

Wetlands

Numerous wetlands occur within the study area. Wetlands are transitional lands between uplands and aquatic systems where water is present at least periodically during the growing season each year and for which the flora and fauna and the nature of soil development are primarily influenced by the presence of water or soil saturated with water. Wetlands perform many valuable functions, such as providing crucial habitat for numerous fish and wildlife species, as well as functions such as water quality improvement, flood control and prevention, groundwater recharge and discharge, erosion control, and education, recreation, and aesthetics that benefit people.

Wetlands occur in association with the MKARNS, its tributaries, and the 15 aforementioned reservoirs in Oklahoma and Arkansas. Wetland types include palustrine, riverine and lacustrine wetlands (Cowardin *et al*., 1979).

Palustrine wetlands include swamps, marshes, forested wetlands (*e.g.*, bottomland hardwoods), bogs, mudflats, fens, and ponds. They can be isolated or occur shoreward of lakes and river channels, on river floodplains, on slopes, or as islands within a lacustrine or riverine system (wetlands within a channel except those dominated by vegetation). They typically are smaller than 20 acres, less than 2 meters deep, and lack significant wave action (Cowardin *et al*., 1979). Palustrine wetlands provide habitat for a wide variety of game, non-game, and fur-bearing species (Table 2).

Riverine wetlands are confined within a channel in which water usually flows. They are typically bounded by upland, a palustrine forested wetland that occurs within the boundaries of a channel, or a forested floodplain (Cowardin *et al*., 1979). Riverine wetlands provide valuable habitat for numerous wildlife species (Table 2). Some of the streams and rivers in the study area, however, have diminished value to fish and wildlife due to impoundment, channelization, and water quality degradation from municipal, industrial, and agricultural effluents. Others, including many of the Ozark streams in Arkansas and Oklahoma, are relatively unaltered. The fisheries in most of these unaltered streams are still considered to be in excellent condition. Lacustrine wetlands include permanently flooded lakes, impounded lakes, oxbow lakes, and intermittent lakes, such as playa lakes (depressions on the plains that seasonally pond during events of high rainfall and vary from a few hundred feet to several miles in diameter). Lacustrine wetlands tend to be large areas of deep water with extensive wave action. They are

bounded by upland or wetland vegetation such as trees, shrubs, emergents, mosses, or lichens. Lacustrine wetlands typically exceed 20 acres in size, occur in topographic depressions or on a dammed river, lack extensive areal vegetative cover (<30 percent) (Cowardin *et al*., 1979), and provide valuable habitat for numerous species that require standing water environments (Table 2). Although not as valuable as the pre-impoundment conditions for many species, impoundments have increased the availability of niches for species that utilize large bodies of standing water, such as warm water lake fish species.

ARKANSAS/VERDIGRIS RIVERS AND 11 OKLAHOMA RESERVOIRS: TERRESTRIAL RESOURCES

Numerous important habitats that support a wide variety of wildlife occur within the project area in Oklahoma and Arkansas. A tentative list of habitat types and associated indicator flora and fauna are presented in Table 2 (USFWS, 1985; USFWS, 1988). These habitat types support numerous game and nongame wildlife within the project area. The list is not inclusive of all species typically found in a particular type, considering the exact species that occur in each habitat type can vary from location to location. The habitat types are subjectively ranked (see Table 2) according to their overall value to fish and wildlife resources. The ratings can vary within habitat types. The following description of the habitat types that may occur within the project area is drawn largely from the Service's reports for a similar study by the Corps on the Arkansas River Basin (USFWS, 1985; USFWS, 1988).

The post oak – blackjack oak forest (crosstimbers) occurs on thin soils prone to erosion if disturbed. Plant species diversity is relatively low; however, the juxtaposition of this forest type with native grasslands greatly increases its value to wildlife.

The oak – hickory forest covers a large portion of the Ozark Plateau in Eastern Oklahoma and Western Arkansas. This forest type tends to have higher species diversity than the crosstimbers, resulting in a potentially greater number of ecological niches for fauna. Tracts adjacent to bottomland hardwood forests and/or riparian forests are especially valuable and provide high quality habitat for many wildlife species.

Native grasslands in the project area consist of tallgrass prairie and mixed-grass prairie. Tallgrass prairie occurs in deep, fertile soil on the eastern and western borders of the crosstimbers and in the Flint Hills. Because of highly fertile soils, much of the tallgrass prairie has been converted to cultivated agriculture and introduced grassland pasture (except in the Flint Hills due to extensive limestone sub-surface). The remaining tracts of tall grass prairie provide valuable wildlife habitat (Table 2). Mixed-grass prairie occurs in scattered tracts in central and western Oklahoma. Much of the mixed-grass prairie has been altered by grazing and agricultural practices; however, the prairie that remains supports numerous wildlife species (Table 2).

Grassland habitats in the project area can be divided into two broad categories determined by the amount of woody cover present. Open field describes grasslands for which less than 25 percent of the area is comprised of woody cover, such as trees and shrubs in early succession stages. Old

field describes grasslands for which more than 25 percent of the area is comprised of woody cover.

Caves generally occur in areas with karst topography (areas of carbonate rock, especially limestone, where sinkholes, springs, and caves have formed as a result of the dissolution of the rock by chemical action). They provide a stable environment and habitat for many animals such as frogs, salamanders, reptiles, bats, snails, isopods, amphipods, crayfish, fish, spiders, and crickets. Although caves are underground habitats, they face many potential threats from activities above ground because they typically are connected to the surface through many openings.

The areal extent of cropland and introduced grassland has increased greatly since settlement and continue to increase often at the expense of natural terrestrial habitats with higher value for fish and wildlife resources. Cropland adjacent or in close proximity to natural habitats can serve as a food source for wildlife species. However, pastures or rangeland with monotypic introduced grasses tend to provide few life requisites for wildlife.

Bottomland hardwood forests occur in floodplains throughout the study area, although few undisturbed tracts remain. In Oklahoma, over 85 percent of the bottomland hardwood forests have been lost, and only a portion of the remaining forest is undisturbed (Oklahoma Water Resources Board, 1990). At one time, about 8 million acres of bottomland hardwood forests occurred in Arkansas. Today, only about 850,000 acres remain, with almost 160,000 of these acres in a contiguous block in the White River NWR. Due to the presence of productive soils, favorable water regimes, and juxtaposition with other habitats, the bottomland forests are one of the most productive habitats in the U. S. (Clark and Clark, 1981), and may be the most important wildlife habitat in the project area.

Riparian forests occur in frequently flooded areas adjacent to streams that have saturated soils and high water tables. They generally occur along tributary streams that lack a well-defined floodplain. The juxtaposition of riparian forest with other habitat types enhances the value of the forest for many species.

DREDGED MATERIAL DISPOSAL SITES

Navigation channel deepening and navigation channel maintenance would require the disposal of dredged material at approved sites along the navigation system. The Corps, ODWC, and the Service have worked cooperatively to minimize the use of environmentally sensitive sites, such as bottomland hardwoods, other wetlands, and important upland forests, as disposal sites. Habitat types at the selected dredged material disposal sites include open field, old field, pasture, cropland, upland floodplain forest (riparian forest), open water, and a small amount of bottomland forest (Table 12). These habitat types are described in more detail in the previous section on aquatic and terrestrial resources.

Wildlife Management Areas

Wildlife management areas (WMAs) managed specifically for wildlife by the ODWC and Corps occur along the MKARNS in the vicinity of Chouteau Lock and Dam in Wagoner County, Webbers Falls Reservoir in Muskogee County, and Robert S. Kerr Reservoir in Haskell and Sequoyah Counties. Nine of the 11 Oklahoma reservoirs that serve as the MKARNS's primary flow modifiers also have WMAs (Table 13). Wildlife management areas in the project area in Arkansas (managed by the AGFC) include Dardanelle, Bayou Meto, Trusten Holder, and Galla Creek (Table 13). The WMAs in both states provide habitat for species such as white-tailed deer, rabbit, squirrel, migratory birds, bobwhite quail, turkey, songbirds, and many species of reptiles and amphibians. These WMAs provide 276,058 acres of public lands available to sportsmen and other outdoor enthusiasts. Agricultural leases also occur within the WMAs that provide important annual revenue to the wildlife departments. Revenue from these leases partially funds the operation and maintenance of the WMAs. A brief description of each WMA is provided below. Detailed information (including some maps) for each WMA is provided on the ODWC and AGFC websites:

- ODWC : http://www.wildlifedepartment.com/wmas2.htm
- AGFC: http://www.agfc.state.ar.us/wma_lakes/wma_all.html.

Copan WMA: The Copan WMA encompasses about 7,500 acres of cross timbers, bottomland hardwood, and tallgrass prairie habitat around the upper end of Copan Reservoir in Washington County, Oklahoma. Aquatic habitats include the reservoir, numerous wetlands, the Little Caney River and its tributaries. Ongoing management practices include developing about 1,000 acres of food plots as well as controlled grazing, and prescribed burning. Six wetland units consisting of about 460 acres have been developed to provide habitat for migratory birds. The water levels in these units are manipulated annually to provide moist soil habitat. The wetland units are used annually by thousands of migratory birds. Game species of interest include white-tailed deer, fox squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, Rio Grande turkey, bobwhite quail, fox and gray squirrel, and waterfowl. The bald eagle and greater prairie chicken *Tympanuchus cupido* also occur on the WMA.

Table 12. Dredged material disposal sites for the navigation channel deepening and navigation channel maintenance elements. Cover type acres were not provided for sites OK 393.1 L-DI and OK 336.3 L-DI. Cover type acres was not fully provided for site OK-318.3 R-DI. For Dredge Disposal Site names: OK = Oklahoma; 398.2 = river mile; R = right bank; L= Left Bank; DI = Direct Impact; PT = Poteau River; SBC = Sans Bois Creek. For Cover Types: OLF = old field; OF = open field; FF = floodplain forest; BLH = bottomland hardwood forest; OW = Open Water; AG = Cropland; BS = barren sand; P = pond.

Disposal Sites	12-ft	9-ft.	Cover Type Acres								Total 12-ft.	Total 9-ft.	Beneficial Use of Dredged Material
			OLF	OF	FF	BLH	OW	AG	BS	P			
OK PR L-DI	X	X		9							9	9	
OK 436.1 L-DI	X			13							13		
OK 422.9 L-DI	X	X		7							7	7	
OK 421.3 R-DI	X			13							13		
OK 312.5 R-DI		X		19								19	
OK 335.9 L-DI	X			22							22		
OK 338.0 R-DI	X			28							28		
OK 443.7 L-DI	X			27							27		
OK 382.0 L-DI	X			23							23		
OK 441.1 L-DI	X			12							12		
OK 401.6 R-DI	X	X		39							39	39	
OK 394.4 L-DI	X							27			27		
OK 393.3 L-DI		X						50				50	
OK 418.5 R-DI	X							33			33		

Table 12 continued

Disposal Sites	12-ft	9-ft.	Cover Type Acres								Total 12-ft.	Total 9-ft.	Beneficial Use of Dredged Material
			OLF	OF	FF	BLH	OW	AG	BS	P			
OK 318.6 L-DI	X								40		40		
OK 375.2 L-DI	X							31			31		
OK 351.9 R-DI	X							14			14		
OK 365.9 R-DI	X							6			6		
OK 396.6 L-DI	X							12			12		
OK 414.2 R-DI (2nd priority)	X							9			9		
OK 429.3 R-DI	X							10			10		
OK 429.4 R-DI	X							14			14		
OK 393.8 L-DI	X							45			45		
OK 391.8 R-DI		X								16		16	
OK 379.1 L-DI	X							31			31		Create wetland
OK 348.3 L-DI (2nd priority)	X	X					20				20	20	Create interior least tern island
OK 389.7 L-DI	X			37							37		
OK 355.0 R-DI		X					31					31	Create interior least tern island
OK 349.4 L-DI		X					20					20	Create interior least tern island
OK 393.1 L-DI		X											Create wetland

Table 12 continued

Disposal Sites	12-ft	9-ft.	Cover Type Acres								Total 12-ft.	Total 9-ft.	Beneficial Use of Dredged Material
			OLF	OF	FF	BLH	OW	AG	BS	P			
OK 336.3 L-DI	X												Beach nourishment
OK 367.2 L-DI	X						32						Marsh creation
OK-SBC 0.4 L-DI	X						100						Marsh creation
OK-SBC 4.8 L-DI	X						94						Marsh creation
OK 336.4 R-DI	X						11						Marsh creation
OK-SBC 6.6 L-DI	X	X					10				10	10	Marsh creation
OK-SBC 6.9 L-DI	X	X					10				10	10	Marsh creation
OK 354 L-DI	X	X					18				18	18	Bank stabilization
OK 345.3 L-DI	X									21	21		Reclaim strip pit
OK 337.2 R-DI	X				28						28		
OK 444.6 R-DI		X			9							9	
OK 444.6 L-DI		X	15									15	
OK 416.4 L-DI	X		14								14		
OK 414.9 R-DI	X		8								8		
OK 366.5 L-DI	X		6								6		
OK 400.0 L-DI		X	23									23	
OK 395.2 L-DI		X	18									18	

Table 12 continued

Disposal Sites	12-ft	9-ft.	Cover Type Acres								Total 12-ft.	Total 9-ft.	Beneficial Use of Dredged Material
			OLF	OF	FF	BLH	OW	AG	BS	P			
OK 394.0 R-DI		X	48									48	
OK 400.7 R-DI	X	X	31								31	31	
OK 434.3 R-DI	X		10								10		
OK 335.8 R-DI	X			14		8					22		
OK-SBC 8.7 L-DI		X	8			2						10	
OK-SBC 9.7 R-DI		X			5	5						10	
OK 383.9 R-DI	X		27	13	2						42		
OK 315.4 R-DI	X	X	28		8						36	36	
OK 318.3 R-DI		X			20							80	
OK-SBC 10.0 R-DI		X	2		16							18	
OK 342.3 L-DI	X		15		14						29		
OK 407.6 R-DI	X		8		2						10		
OK 309.1 R-DI	X	X		23	5						28	28	
OK 420.8 L-DI		X		43	10							63	
OK 398.2 R-DI	X		10	34							44		
Total Acres											**889**	**638**	

Table 13. Wildlife Management Areas associated with the MKARNS in Oklahoma and Arkansas.

Wildlife Management Areas	Acres
Oklahoma	186,229
Copan	7,500
Hulah	16,141
Oologah	14,155
Kaw	16,254
Keystone	16,537
Fort Gibson	21,798
Tenkiller	1,950
Eufaula	48,469
Wister	35,550
McClellan Kerr	7,875
Arkansas	89, 829
Dardanelle	42,500
Bayou Meto	34,000
Trusten Holder	10,000
Galla Creek	3,329
Total	276,058

Hulah WMA: The Hulah WMA consists of about 16,000 acres of bottomland hardwood forest, tallgrass prairie, and post oak/blackjack oak forest in Osage County, Oklahoma.

Aquatic habitats include the reservoir, numerous small ponds, the Caney River and its tributary streams. Ongoing management practices include controlled grazing, agricultural plantings on about 2,200 acres, and prescribed burning. Two wetlands units have been developed that require water level manipulations to provide about 260 acres of moist soil habitat for migratory birds. Popular game species include white-tailed deer, fox and gray squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, Rio Grande turkey, mourning dove, bobwhite quail, and waterfowl. Other species of interest that occur on the WMA include the bald eagle and greater prairie chicken.

Oologah WMA: The WMA consists of about 13,000 acres around Oologah Lake in Rogers and Nowata Counties, Oklahoma. The area primarily provides bottomland hardwood habitat for native wildlife species. Pecan, oak, and willow are the dominant tree species in the bottomlands. Old field and native prairie habitat also occur on the area. Aquatic habitats include emergent wetlands, ponds, and the Verdigris River and its tributaries. Management efforts are directed at maintaining native plant species. About 1,000 acres of food plots and agricultural leases also are utilized to provide additional wildlife food sources. The Overcup Bottoms and Upper Verdigris Units consist of wetland development areas managed for waterfowl. Popular game species include white-tailed deer, fox and gray squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, Rio Grande turkey, mourning dove, bobwhite quail, and waterfowl. The bald eagle occurs in the area during the winter.

Kaw WMA: The WMA is located along the upper 2/3 of Kaw Reservoir including the Arkansas River, Beaver Creek, Little Beaver Creek, and Bear Creek in Kay County, Oklahoma. The area consists of about 16,000 acres of cropland, upland oak forest, bottomland hardwoods, old fields, and tallgrass prairie. Native bluestem grasses predominate on the prairie sites. Post oak, blackjack oak and sand plum are the most common tree species in the upland forested areas. Predominant trees in the bottomlands are hackberry, burr oak, and sycamore. Aquatic habitats include the Arkansas River, Beaver Creek, Little Beaver Creek, Bear Creek and their tributaries, and wetlands. Management practices include: 1) leasing about 4,000 acres to be planted in milo, corn, wheat, and soy beans, 2) planting about 1,000 acres of mud flats in Japanese millet that are inundated when the plants mature (to increase waterfowl habitat), and 3) planting trees and shrubs to enhance upland habitat. Popular game species include white-tailed deer, fox squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, Rio Grande turkey, mourning dove, bobwhite quail, pheasant, and waterfowl. The bald eagle occurs at the reservoir/WMA in large numbers during the winter, and also is known to nest in the area. Other species of interest include the greater prairie chicken, osprey *Pandion haliaetus*, upland sandpiper *Bartramia longicauda*, and the Texas horned lizard *Phrynosoma cornutum*.

Keystone WMA: The WMA encompasses about 16,500 acres located along the Arkansas and Cimarron Rivers above Keystone Reservoir in Creek, Osage and Pawnee Counties. Fish and Wildlife habitat include the wide, shallow rivers, their tributaries and sandbars, riparian areas adjacent to the rivers (dominated by cottonwood and willow), wetlands, sloughs, mudflats,

bottomland hardwoods, crop fields, fallow crop fields, and some post oak-blackjack oak uplands. Management practices include enhancing/maintaining native vegetation, food plot plantings, agricultural leases, and prescribed burns. Popular game species include white-tailed deer, fox squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, Rio Grande turkey, mourning dove, bobwhite quail, and waterfowl. The bald eagle nests and winters in the area.

Fort Gibson WMA: The area consists of a mixture of tallgrass prairie, farm fields, post oak-blackjack oak woods, and bottomlands on about 21,800 acres in Wagoner and Cherokee Counties, Oklahoma. Prescribed burning and row crops enhance upland habitats. A waterfowl refuge with nine wetland units occurs on about 3,500 acres. Popular game species include white-tailed deer, fox squirrel, cottontail rabbit, raccoon, coyote, bobcat, beaver, mourning dove, bobwhite quail, and waterfowl. The bald eagle winters in the area.

Tenkiller WMA: The WMA contains about 2,590 acres of oak/hickory upland and riparian habitat adjacent to Tenkiller reservoir in Cherokee and Sequoyah Counties, Oklahoma. Riparian species primarily are elm, willow, river birch, hackberry, and sycamore. Management practices include planting food plots and thinning upland wooded areas. Popular game species include white-tailed deer, fox and gray squirrel, cottontail rabbit, raccoon, coyote, gray fox, bobcat, beaver, turkey, mourning dove, bobwhite quail, and waterfowl. The bald eagle winters and nests in the area.

Eufaula WMA: The WMA occurs on about 48,615 acres in Latimer, McIntosh, Pittsburg, and Cherokee Counties, Oklahoma. The area consists primarily of floodplain and bottomland hardwoods supporting of a variety of tree species such as pin oak, willow, and sycamore. Numerous natural wetlands and sloughs occur on the WMA. About 780 acres have been developed into wetland units managed for waterfowl. Mixed upland hardwoods, prairie, and old fields also occur on the area. About 1,500 acres are farmed through lease agreements to provide additional food sources for wildlife. Popular game species include white-tailed deer, fox and gray squirrel, cottontail rabbit, raccoon, coyote, gray fox, bobcat, beaver, turkey, mourning dove, bobwhite quail, and waterfowl. The bald eagle winters and nests in the area.

Wister WMA: The WMA contains about 35,500 acres of bottomland hardwoods along the Poteau and Fourche Maline Rivers, with prairie and oak/hickory/pine forest in the uplands. The WMA is located in LeFlore and Latimer Counties, Oklahoma. Ongoing management focuses on maintaining openings and controlling woody vegetation. Practices include prescribed burning, strip discing, brush hogging, and planting food plots. Controlled grazing is allowed on about 14,000 acres. Popular game species include white-tailed deer, fox and gray squirrel, cottontail rabbit, raccoon, coyote, gray fox, bobcat, beaver, turkey, mourning dove, bobwhite quail, and waterfowl. Black bear are present in low numbers. The bald eagle winters and nests in the area. The golden eagle also winters in the area.

Dardanelle WMA: The area consists of about 45,000 acres of uplands and wetlands in Pope, Yell, Johnson, and Logan Counties, Arkansas. Popular game species include white-tailed deer, coyote, cottontail and swamp rabbit, bobwhite quail, mourning dove, American woodcock, and waterfowl.

Bayou Meto: The WMA consists of about 31,830 acres in Jefferson and Arkansas Counties, Arkansas. The area provides both upland and wetland habitats including six lakes totaling 1,080 acres. Numerous water control structures are used to manipulate water on the area to benefit waterfowl. About 13,000 acres are flooded each fall to provide habitat for migrating waterfowl. Other management practices include controlled burning, brush hogging, strip discing, and planting food plots. Popular game species include whitetail deer, raccoon, cottontail rabbit, fox squirrel, turkey, and waterfowl. The American alligator also occurs on the WMA.

Trusten Holder: The WMA contains about 4,400 acres of overflow bottomland hardwoods adjacent to the White River in Desha and Arkansas Counties, Arkansas. Typical tree species include overcup and nuttal oak, hackberry, ash, and persimmon. Management practices include selective timber harvest, controlled burns, and planting food plots. Popular game species include whitetail deer, squirrel, cottontail and swamp rabbit, bobwhite quail, mourning dove, and waterfowl.

Galla Creek: The WMA contains about 3,330 acres in two tracts located north of Holla Bend NWR and the Arkansas River in Pope and Yell Counties, Arkansas. The area contains both upland forests, wetlands, and a lake on Galla Creek. Popular game species include whitetail deer, fox and gray squirrel, raccoon, cottontail and swamp rabbit, mourning dove, American woodcock, bobwhite quail, and waterfowl.

National Wildlife Refuges

Three NWRs occur along or near the MKARNS. The refuges are the Sequoyah NWR in eastern Oklahoma, and the Holla Bend and White River NWRs in Arkansas.

Sequoyah NWR: The refuge occurs in Haskell, Muskogee, and Sequoyah Counties near the confluence of the Arkansas and Canadian Rivers in Oklahoma. The refuge was established by cooperative agreement between the Service and the Corps in 1970 to provide habitat for waterfowl and other migratory birds. The refuge covers about 20,800 acres and annually hosts the largest concentration of wintering snow geese in Oklahoma. Bottomland hardwood habitat found at the refuge provides habitat for numerous wildlife species such as songbirds, raptors, quail, rabbit, muskrat, deer, bobcat, and squirrels, as well as many species of reptiles and amphibians including the green tree frog, cottonmouth, red-eared slider, diamondback water snake, and bullfrog. The bald eagle is common at the refuge during the fall and winter. The refuge also appears to be one of the last strongholds in Oklahoma for the alligator snapping turtle, a state species of special concern in Oklahoma.

Sequoyah NWR offers the public opportunities for hiking, wildlife photography, bird watching, and freshwater fishing. Public hunting is allowed for waterfowl, deer, and small game (rabbit, grey squirrel, fox squirrel, American coot, snipe, mourning dove, woodcock, and bobwhite quail).

Holla Bend NWR: The refuge is located in west-central Arkansas along the Arkansas River in Pope County. This refuge was established in 1957 and encompasses 7,057 acres of bottomland

hardwoods and wetlands. The refuge is bounded to the north by an oxbow lake created when the Corps excavated a channel through the bend in the river to improve the MKARNS for navigation and flood control. Wildlife resources at the refuge include several species of wintering waterfowl, the golden eagle, the federally-listed threatened bald eagle, migratory songbirds, as well as many species of mammals, reptiles, and amphibians. The refuge receives about 40,000 visitors annually and offers the public opportunities for hiking, wildlife photography, hunting, bird watching, and freshwater fishing.

White River NWR: The refuge occurs in Desha, Monroe, and Phillips Counties in eastern Arkansas and lies in the floodplain of the lower White River near the confluence of the Arkansas and Mississippi Rivers. The refuge encompasses 90 of the lower 100 miles of the White River in Arkansas as well as three miles of the Arkansas Post Canal. Established in 1935, the refuge is about 160,000 acres in size, including about 154,000 acres of bottomland hardwood forests forest, 1,000 acres of grassland, 900 acres of cropland, and 4,000 acres of natural and manmade lakes. Although historically about 8 million acres of bottomland hardwood forests occurred in Arkansas, today only about 850,000 acres remain. The bottomland hardwood forest within the refuge represents nearly 20 percent of the state's remaining bottomland hardwood forest acreage. The refuge is one of the largest remaining contiguous bottomland hardwood forests in the lower Mississippi River Valley.

The refuge has been designated as a Wetland of International Importance and is on the American Bird Conservancy list of globally important bird areas. As the host of the largest concentration of wintering mallard ducks in the Mississippi Flyway, the refuge helps bring about 2.5 million dollars per day to the area during the sixty day waterfowl hunting season. Thus, the refuge is a major economic asset to the area. The area provides habitat for wading birds, shorebirds, waterfowl, raptors, a variety of reptiles, amphibians, and mammals, including a healthy population of black bears. The refuge also has four active nests of the federally-listed threatened bald eagle. White River NWR is visited by about 150,000 people annually and offers opportunities for hunting, boating, fishing, wildlife observation and photography, and hiking.

THREATENED AND ENDANGERED SPECIES

Section 7(a)(2) of the Endangered Species Act (ESA) requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any federally-listed threatened or endangered species or result in adverse modification or destruction of designated critical habitat. When the federal action agency, in this case the Corps, determines that its action "may affect" a federally-listed threatened or endangered species or designated critical habitat, the agency is required to enter into formal consultation with the Service. The federal agency or their designated non-federal representative would prepare a biological assessment that addresses possible impacts to the federally-listed species that occur within the project area.

Seventeen federally-listed endangered and threatened species and two candidates for federal listing occur within the vicinity of the project area. Specific information relative to these species is included in Appendix B.

Formal consultation under section 7 of the ESA is nearing completion for the following four species: 1) the interior least tern, 2) the American burying beetle, 3) the bald eagle, and 4) the pallid sturgeon. The Service has recommended that the Corps (and the Federal Energy Regulatory Commission) also formally consult with the Service on the operation of Grand Lake to address incidental take related to the operation of this reservoir. This consultation will be conducted separate from the ongoing consultation pertaining to ARNS.

STATE LISTED AND OTHER RARE/DECLINING SPECIES

Other species that also should be considered during project planning include state-listed and rare species, species with restricted ranges, and species of conservation concern that may occur within the project area (Tables 14 and 15). Rare/declining, state-listed threatened or endangered species, and species of concern are not afforded protection under the ESA, unless proposed for federal listing. However, protection of these species now may help prevent the need to list them in the future.

ZEBRA MUSSELS

The zebra mussel *Dreissena polymorpha* is a small (thumbnail size) mussel with alternating light and dark stripes native to the Caspian Sea Region of Asia. This species, native to the Caspian Sea Region of Asia, has spread throughout the eastern United States since its unintentional introduction in the Great Lakes around 1986 in the ballast water of ships and on the hulls of barges. They are now found in at least 20 states, including Oklahoma and Arkansas.

Zebra mussels adversely impact infested aquatic habitats (D'Itri, 1997). They occur in large, dense clusters of up to 30,000 individuals in one square meter (O'Neill and MacNeill, 1991). Zebra mussels are known to smother native mussel fauna. They also can alter the natural food chain by consuming food otherwise available to native species, alter habitat substrates, and impact water quality.

Table 14. State-listed rare and endangered/threatened species that occur or may occur within the project area in Oklahoma.

Species	State Status[1]	Distribution and/or typical habitat in Study Area
Animals		
Gray bat (*Myotis grisescens*)	E	northeastern OK; limestone caves, forests near rivers/lakes
Indiana bat (*Myotis sodalis*)	E	eastern OK; caves, forests
Ozark big-eared bat (*Plecotus townsendii ingens*)	E	northeastern OK; caves (karst areas) in oak-hickory forests
Marsh rice rat (*Oryzomys palustris*)	SS2	eastern OK; near wetlands, grasslands
Golden mouse (*Ochrotomys nuttali*)	SS2	east-central OK; greenbriar thickets, swamps
Long-tailed weasel (*Mustela frenata*)	SS2	variety of habitats statewide
Mountain lion (*Felis concolor*)	SS2	rare in eastern OK
Rafinesque's big-eared bat (*Plecotus rafinesqui*)	SS2	east-central Oklahoma; forests with dense foliage
River otter (*Lutra canadensis*)	SS2	eastern OK, Wister WMA; aquatic
Woodchuck (*Marmota monax*)	SS2	east-central & northeastern OK; open woodlands
Piping plover (*Charadrius melodus*)	T	migrates through central and eastern OK; known to use Winganon Flats at Oologah Reservoir
Bald eagle (*Haliaeetus leucocephalus*)	E	major rivers and reservoirs
Interior least tern (*Sterna antillarum athalassos*)	E	Arkansas and Canadian Rivers
Prairie falcon (*Falco mexicanus*)	SS1	dry plains and prairies
Swainson's hawk (*Buteo swainsoni*)	SS2	grasslands
Migrant loggerhead shrike (*Lanius ludovicianus migrans*)	SS2	open areas with high perches

Table 14 continued

Species	State Status[1]	Distribution and/or typical habitat in Study Area
Barn owl (*Tyto alba*)	SS2	woodlands, savannas, farmlands, suburbs
Bell's Vireo (*Vireo bellii*)	SS2	deciduous thickets along streams, ravines, forest edges
Arkansas darter (*Etheostoma cragini*)	SS2	northeastern Oklahoma; northwestern Arkansas; spring feed vegetated creeks and headwaters typically over mud
Arkansas River shiner (*Notropis girardi*)	T	Canadian River above Eufaula Reservoir
Ozark cavefish (*Amblyopsis rosae*)	T	streams in nutrient rich caves in northeastern OK/Ozark highlands
Blackside darter (*Percina maculata*)	T	eastern OK in pools of creeks of small-medium rivers
Longnose darter (*Percina nasuta*)	E	east-central OK in gravel runs of small-medium rivers
Alabama shad (*Alosa alabame*)	SS2	east-central and northeast OK in open water of medium - large rivers
Alligator gar (*Atractosteus spatula*)	SS2	eastern OK except northeast in pools and backwaters of rivers, lakes, swamps
Peppered chub (*Macrhybopsis tetranema*)	SS2	gravel runs of major rivers and tributaries
Blue sucker (*Cycleptus elongates*)	SS2	Grand lake and tailwaters
Black buffalo (*Ictiobus niger*)	SS2	eastern and central OK in rivers and lakes
Bluntface shiner (*Cyprinella camura*)	SS2	northeastern OK in small clear streams

Table 14 continued

Species	State Status[1]	Distribution and/or typical habitat in Study Area
Harlequin darter (*Etheostoma histrio*)	SS2	mostly Saline, Spavinaw, and Spring Creeks
Kiamichi shiner (*Notropis ortenburgeri*)	SS2	Poteau River and streams in Ouachita Mountains
Pallid shiner (*Hybopsis amnis*)	SS2	Poteau River
Plains topminnow (*Fundulus sciadicus*)	SS2	Grand River drainage
Ribbon shiner (*Lythrurus fumeus)*	SS2	Illinois and Poteau Rivers
River Darter (*Percina shumardi*)	SS2	Grand and Illinois Rivers
Shorthead redhorse (*Moxostoma macrolepidotum*)	SS2	northeastern OK in clear gravel-bottom streams/rivers
Shovelnose sturgeon (*Scaphirhyncus platorynchus*)	SS2	Arkansas River and tributaries
Southern brook lamprey (*Ichthyomyzon gagei*)	SS2	clear streams of Ouachitas and Ozarks
Spotfin shiner (*Notropis spilopterus*)	SS2	Illinois River
Spotted bass (*Micropterus punctulatus)*	SS2	eastern OK in clear, spring- fed streams
Stonecat (*Notorus flavus*)	SS2	northeatern OK in clear bottom, gravel streams
Northern scarlet snake (*Cemophora coccinea*)	SS2	eastern OK in sandy/loamy areas
Alligator snapping turtle (*Macroclemys temminckii*)	SS2	Eastern OK in lakes, rivers, oxbows, and sloughs; known to occur at Seqouyah NWR and near Eufaula Reservoir
Map turtle (*Graptemys geographica*)	SS2	Delaware County; large bodies of water

Table 14 continued

Species	State Status[1]	Distribution and/or typical habitat in Study Area
Texas horned lizard (*Phrynosoma cornutum*)	SS2	grasslands with areas of sparse vegetation
Rich Mountain salamander (*Plethodon ouachitae*)	SS2	north facing talus slopes of Ouachtia Mountains
Grotto salamander (*Typhlotriton spelaeus)*	SS2	northeastern OK in limestone caves with springs
Oklahoma salamander (*Eurycea tynerensis*)	SS2	northeast OK in spring-fed creeks with gravel bottoms
Ouachita dusky salamander (*Desmognathus brimleyorum*)	SS2	southeastern OK in springs, streams
Ringed salamander (*Ambystoma annulatum*)	SS2	eastern OK in moist wooded areas
Scaleshell (*Leptodea leptodon*)	SS2	scattered populations in Arkansas River Basin
Neosho mucket (*Lampsilis rafinesqueana*)	E	Illinois River above Lake Tenkiller
Western fanshell (*Cyprogenia aberti*)	SS2	historically occurred in Verdigris and Caney Rivers ; may be extirpated from Oklahoma
Spectacle-case shell (*Quadrula cylindrica*)	SS2	Illinois River in Cherokee County
Rich Mountain slitmouth (*Stenotrema pilsbryi*)	SS1	talus slope in Ouachita Mountains
American Burying Beetle (*Nicrophorus americanus*)	E	habitat generalist; grasslands, forests
Prairie mole cricket (*Gryllotalpa major*)	SS2	prairies
Plants		
Ozark chinquapin oak (*Castenea pumela* var. *ozarkensis*	R	eastern OK in oak-pine and oak-hickory forests

Table 14 continued

Species	State Status[1]	Distribution and/or typical habitat in Study Area
Waterfall's sedge (Carex latebracteata)	R	mesic slopes in southeastern OK
Hammock sedge (Carex fissa)	R	northeastern OK along edges of ponds/lakes
Ozark wake-robin (Trillium pusillum var. ozarkanum)	R	oak-hickory and oak-pine woodlands in LeFlore County
Ozark spiderwort (Tradescantia ozarkana)	R	eastern OK in deciduous forests in ravines and steep rocky hillsides
Skinner's false foxglove (Agalinis skinneriana)	R	Delaware County in prairies and open areas of oak-hickory forests but may be extirpated from OK
Earleaf false-foxglove (Agalinis auriculata)	R	currently only known from prairie hay meadows bordered by upland woods in Choctaw County
Dwarf pipewort (Eriocaulon kornickianum)	R	sandy hillsides in Atoka, Muskogee, and Pushmataha Counties
Southern Lady's slipper (Cyprepedium kentuckiense)	R	southeastern OK in floodplain forests and mesic ravines
Ouachita indigo bush (Amorpha ouachitensis)	R	Leflore, McCurtain, and Pushmataha Counties along rocky creeks, streambanks, and floodplains
Western prairie fringed orchid (Platanthera praeclara)	T	northeastern Oklahoma in moist grasslands; may be extirpated from Oklahoma

E = Endangered
T = Threatened
SS1 = Species of Special Concern where current evidence indicates species is vulnerable because of limited range, low population, or other factors
SS2 = Species of Special Concern that is possibly threatened or vulnerable but with little evidence to document current population levels and range.
R = Rare

Table 15. Arkansas state-listed rare species that occur or may occur within the project area (list of species and their state rank provided by the Arkansas Natural Heritage Commission).

Species	State Rank[1]	Distribution in Arkansas and/or typical habitat
Animals		
Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)	S2	statewide except Ozark Mountains; occupies buildings, barns, caves, forests
Brazilian free-tailed bat (*Tadarida brasiliensis*)	S3	central and southern Arkansas; occupies buildings, forests
Gray myotis (*Myotis grisescens*)	S2	forests and caves near rivers, lakes
Florida panther (*Puma concolor coryi*)	SH	–
Swainson's warbler (*Limnothlypis swainsonii*)	S3B	possibly statewide; swamp forests, bottomland hardwood forests, riparian forests
Interior least tern (*Sterna antillarum athalassos*)	S2B	sand bars on Arkansas and White Rivers
Bald eagle (*Haliaeetus leucocephalus*)	S2B, S4N	statewide; rivers, reservoirs/lakes
Strecker's chorus frog (*Pseudacris streckeri streckeri*)	S2	eastern and central Arkansas; moist woods, rocky ravines, riparian forests, lagoons, swamp forests, croplands
Plains spadefoot (*Scaphiopus bombifrons*)	S1	isolated population in north-central/northwest Arkansas; grasslands
Arkansas River shiner (*Notropis girardi*)	SX	–
Shorthead redhorse (*Moxostoma macrolepidotum*)	S2	northern half of Arkansas; rocky pools and riffles of small and large rivers, lakes
Slenderhead darter (*Percina phoxocephala*)	S2	western Arkansas; gravel runs and riffles of small creeks to medium rivers

Table 15 continued

Species	State Rank[1]	Distribution in Arkansas and/or typical habitat
Suckermouth minnow (*Phenacobius mirabilis*)	S1	west-central Arkansas; gravel/rubble riffles and runs of creeks, and in small to large rivers
Flathead chub (*Platygobio gracilis*)	S1?	eastern Arkansas; sandy runs of rivers
Paddlefish (*Polyodon spathula*)	S1, S2	statewide; slow flowing, deep water of large rivers
Swamp darter (*Etheostoma fusiforme*)	S2, S3	south and eastern Arkansas; standing of slow-moving water over sand or mud
Goldeye (*Hiodon alosoides*)	S2B, S4N	statewide; occurs in deep open pools, channels, lowland rivers, lakes.
Plains minnow (*Hybognathus placitus*)	SX	west-central Arkansas; shallow sandy runs, pools of creeks, and small to large rivers
Lake sturgeon (*Acipenser fulvescens*)	S1	eastern Arkansas; bottom of lakes and large rivers
Lake chubsucker (*Erimyzon sucetta)*	S3	southern, east-central, and eastern Arkansas; lakes, ponds, and swamps over silt, sand, or debris
Plants		
San Antonio false-foxglove (*Agalinis homalantha*)	S1	statewide; oak woodlands
Texas bergia (*Bergia texana*)	S2	Johnson , Perry, ansd Desha Coutnies; swamps, mud flats, muddy pond shores
Tissue sedge (*Carex hyalina*)	S3	statewide inventory needed; margins of forested wetlands and swamps
Scratch-daisy (*Croptilon hookerianum* var. *validum*)	S2	limited to the Arkansas Valley and Mississippi Alluvial Plain

Table 15 continued

Species	State Rank[1]	Distribution in Arkansas and/or typical habitat
Lax hornpod (*Cynoctonum mitreola*)	S3	wetlands
Six-angle spurge (*Euphorbia hexagona*)	S2	known to occur in Franklin and Pope Counties; sandy shores and bottoms
Showy prairie-gentian (*Eustoma russellienum*)	S2	Clark County and Arkansas River Valley
Soapwart gentian (*Gentiana saponaria*)	S3	western and central Arkansas; swamps, bogs
Hairy water-fern (*Marsilea vestita*)	S3	Arkansas River Valley and in Bradley, Chicot, Washington and Polk Counties; wetlands
California bullrush (*Scirpus californicus*)	S1S2	known to occur in Hempstead, Johnson, and Conway Counties; wetlands
Riddell's spike moss (*Selaginella arenicola*)	S3	known from the Ozark Plateau; dry rocks and packed sand
Twistflower (*Streptanthus obtusfolius*)	S3	restricted to Ouachita Mountains

S1 = Extremely rare. Typically 5 or fewer estimated occurrences in the state, or only a few remaining individuals, may be especially vulnerable to extirpation.
S2 = Very rare. Typically between 5 and 20 estimated occurrences or with many individuals in fewer occurrences, often susceptible to becoming extirpated.
S3 = Rare to uncommon. Typically between 20 and 100 estimated occurrences, may have fewer occurrences but with many large number of individuals in some populations, may be susceptible to immediate threats.
S4 = Common, apparently secure under present conditions. Typically 100 or more estimated occurrences but with large number of individuals in some populations, may be restricted to only a portion of the state.
SH = Historical occurrence but may be extirpated
SX = Believed to be extirpated.
? = Indecision regarding rank assignment
B = Breeding status
N = Non-breeding status

Zebra mussels spread primarily by attaching to boats used in infested waters that are then launched on lakes they have not been invaded. The mussels and their veligers can be carried in bilges, minnow buckets, live wells, and engine cooling systems. They populate a new body of water quickly due to their high reproductive rate (*e.g.*, a female can release up to one million eggs each season) and their few natural predators (*e.g.*, diving ducks, blue catfish, red ear sunfish, and freshwater drum).

Eliminating established populations is impossible. Washing and scrubbing boats and equipment that have been used in infested waters currently is the best method to prevent further spread of this species.

Zebra mussels are known to occur throughout the project area with concentrations established at the following locations: 1) lock and dam # 10 (Dardanelle) on the Arkansas River, 2) Arkansas Nuclear One intake canal and effluent bay (Lake Dardanelle), 3) lock and dam # 14 (W. D. Mayo) on the Arkansas River; 4) lock and dam # 15 (Robert S. Kerr) on the Arkansas River; 5) lock and dam # 16 (Webbers Falls) on the Arkansas River; 6) lock and dam # 17 (Choteau) on the Verdigris River; 7) lock and dam # 18 (Newt Graham) on the Verdigris River; 7) at Oologah Lake on the Verdigris River, and 8) Kaw Reservoir.

FISH AND WILDLIFE RESOURCES: FUTURE WITHOUT THE PROJECT

The future conditions for fish and wildlife resources are difficult to accurately predict due to the large areal extent of the project area and complex nature of the project. Habitat improvements along the system, such as riparian restoration and dike notching, are likely to continue through various available means such as section 1135 (Project Modifications for the Improvement of the Environment) of Water Resources Development Act (WRDA) of 1986, Section 206 (Aquatic Ecosystem Restoration) of WRDA 1996, landowner incentive measures of the Farm Bill, and the Service's Partners for Fish and Wildlife Program.

Sixty-two fish species were identified within the navigation system from the aquatic impact assessment conducted during Summer 2004. Although Buchanan's (1976) assessment identified 106 fish species within the navigation system, his study also included tributaries and the White River. The 2004 assessment restricted sampling primarily to tail waters, which largely accounts for the disparity in the number of fish species reported from these sources.

Construction and ongoing operation of the MKARNS has resulted in stabilized channel conditions, and the creation of reservoirs that provide habitat for lake species, but limit habitat for native riverine species. The overall result is a more homogenous aquatic environment within the MKARNS that benefits particular fish and mussel fauna at the expense of others (Buchanan, 1976). The Corps likely would continue to maintain commercial navigation on the MKARNS at the current 9-foot navigation depth if the proposed project were not implemented. Thus, the navigation system and reservoirs would continue to provide a relatively homogenous aquatic environment. The overall fish and mussel fauna would be expected to be similar to existing conditions without the proposed project.

Changes to aquatic resources in the reservoirs on the system would occur as the reservoirs continue to age. The upper ends of the reservoirs will continue to become more shallow and convert to marsh habitat as they fill in with sediments deposited by the incoming watercourse. The natural process of eutrophication also would continue, especially in the shallow reservoir headwaters.

Other changes may occur as newly developed or modified lake level management plans are implemented or stocking/restoration efforts are pursued. Management of biotic resources would continue and are likely to be beneficial to fish and wildlife species.

Wildlife Management Areas and NWRs along the MKARNS in both states and at the Oklahoma reservoirs that serve as the MKARNS's primary flow modifiers are expected to continue to be managed specifically for fish and wildlife resources by the ODWC, AGFC, Corps and the Service. Changes may occur as a result of natural succession and modified management plans, but are anticipated to be beneficial due to continued management practices. Natural species succession also would be expected to occur in most of the terrestrial cover types described previously.

Federally-listed species are afforded protection under the ESA, as amended. The ESA provides a framework for the federal government, states, private industry and individuals to work cooperatively to conserve listed species. Conservation and protection of listed species is anticipated to continue through federal, state, and private recovery actions, future research studies and monitoring efforts, interagency consultations, and the implementation of conservation measures on private land.

Rare/declining, state-listed threatened and endangered species, and other species of concern are not afforded protection under the ESA. Continued population declines may occur, warranting listing and subsequent federal recovery efforts. Protection of these species now will help prevent the need to list them in the future. Various federal initiatives, for example, the State Wildlife Grants program authorized by the Department of the Interior and Related Agencies Appropriations Act, 2004, provide millions of dollars in wildlife conservation grants to the states, tribes, and private organizations. These grants will be used to benefit wildlife and their habitat, including rare/declining, state-listed threatened or endangered species, and other species of concern.

The population of paddlefish within the navigation system likely would remain stable or increase. Existing gravel bars should continue to support spawning habitat for the paddlefish. Also, restoration attempts and surveys on the brood stock of paddlefish in the Arkansas and Verdigris rivers in northeastern Oklahoma are expected to be on-going without the project.

A task force to address the spread of zebra mussels, known as the 100th Meridian Initiative, has been formed with representatives from federal and state agencies, private industry, and user groups. Eliminating an established population of zebra mussels is difficult to impossible. Zebra mussels possess a high reproductive rate and have limited natural predators within the project area. For these reasons, zebra mussels can rapidly populate a new body of water. Further spread

of this species within the project area may occur, for example, should a boat from infested waters be moved to non-infested waters.

SUMMARY OF PLAN SELECTION PROCESS AND IDENTIFICATION OF EVALUATED ALTERNATIVES

The proposed action for the study objectives consists of three features that influence navigation: 1) River Flow Management, 2) Navigation Channel Deepening, and 3) Navigation Channel Maintenance. Within each feature, numerous project components were examined as part of the study. Project Alternatives (combinations of components from the three features) were then developed to address the attainment of the study purpose. We briefly describe the components of each feature and the alternatives that were analyzed here. The Corps draft Environmental Impact Statement (USACOE, 2005a) and Feasibility Report (USACOE, 2005b) provides a more detailed description of the components and alternatives evaluated, and the selected plan.

The project can initially be divided into two major elements, the No Project element and the Action element. The "No Project" element would only occur if none of the components within each feature were selected. We do not anticipate this element would be selected due to the lack of existing dredged material containment/disposal areas for anticipated ongoing maintenance activities with the existing nine-foot channel (see discussion under Navigation Channel Maintenance feature).

RIVER FLOW MANAGEMENT FEATURE

The study team initially examined nine structural components and three non-structural components. The structural components were:

- Construction of an extensive levee system in the Oklahoma portion of the study area;
- Evacuation of water from the upper MKARNS;
- Construction of one or more new reservoirs;
- Pre-release of water from the Oklahoma reservoirs based upon short-term weather forecasts;
- Removal of channel restrictions such as training dikes;
- Modification of existing in-stream navigation structures;
- Removal of locks and dams throughout the MKARNS;
- Construction of high flow relief structures; and

- Restoration/enhancement of aquatic and riparian habitats along the MKARNS;

The non-structural project components considered included:

- Modification of flow rates and durations, primarily associated with the operation of the 11 Oklahoma reservoirs;

- Reallocation of reservoir storage from one project purpose to another; and

- Adjustments/increases in flowage easements.

The study team determined that only the non-structural components met the project objectives established for the study and that structural components would be too expensive relative to the associated benefits. A total of twenty-three specific non-structural components were evaluated and compared using the Corps Southwest Division SUPER Model. Detailed information associated with the SUPER Model screening runs can be found in Appendix A, Hydrology and Hydraulics Report, of the draft Feasibility Report (USACOE, 2005b). Four operational components, including a No Action component, were selected from this evaluation and examined in detail.

The "No Action" Component consists of maintaining the current operating plan that includes five release zones: 1) 150,000 cfs, 2) 150,000 to 105,000 cfs, 3) 75,000 cfs, 4) 75,000 to 40,000 cfs, and 5) 40,000 to 20,000 cfs. The No Action Alternative includes a 75,000 cfs bench (*i.e.*, period of time where the flow is held at or below 75,000 cfs.) The bench is adjusted seasonally to minimize flood impacts and maximize benefits to farmland. No changes to the existing rivers or reservoirs would be made.

The detailed analysis of the three action components involved a major hydraulics study, modeling runs of the river system, and an economics study for each proposed alternative (USACOE, 2005a and b). Each action component would change the number of days that river flows would exceed certain flow conditions at Van Buren, Arkansas (Table 16). The components are briefly described below.

Table 16. The difference in the number of days that river flows would exceed certain flow conditions at Van Buren, Arkansas, under the Action Components.

River Flow at Van Buren	Component 2: 175,000 cfs Plan	Component 3: 200,000 cfs plan	Component 4: Operations Only Plan
Difference in days above 60,000 cfs	-9	-9	-14
Difference in Dyas above 100,000 cfs	-16	-17	+2
Difference in days above 137,000 cfs	-4	-5	0
Difference in days above 175,000 cfs	+4.3	+7.1	0

Component 2 consists of increasing the target operating flows at Van Buren to 175,000 cfs with a 60,000 cfs bench (replacing the existing 75,000 cfs bench) lowered 3 percent (*i.e.*, from 18 to 15 percent system full) except from June 15– October 1.

Component 3 consists of operating Van Buren at 200,000 cfs with a 60,000 cfs bench replacing the 75,000 cfs bench lowered 3 percent except from June 15 – October 1.

Component 4 is the operations only plan. This component consists of maintaining the existing operating plan (*i.e.*, operating Van Buren at 150,000 cfs), but replacing the current 75,000 cfs bench with a 60,000 cfs bench beginning at 3 percent lower system storage except from June 15 – October 1.

Component 4 is the Corps recommended component for the River Flow Management feature, and was selected based on three primary differences from the existing plan (*i.e.*, the No Action component): 1) a reduction of 14 days below 61,000 cfs (a key level for farming interests in Arkansas and navigation interests), 2) an increase in days between 40,000 cfs and 60,000 cfs (key to scouring flows in the navigation system), and 3) accelerated evacuation of the storage projects when the system exceeds 75 percent full. This component was carried forward for inclusion in the development of project alternatives.

NAVIGATION CHANNEL DEEPENING FEATURE

The screening process included the evaluation of four major components:

- Navigation Channel Deepening via Dredging;
- Navigation Channel Deepening via Pool Raising;
- Navigation Channel Deepening via a combination of Dredging and Pool Raising; and
- Verdigris River Navigation Channel Widening.

Only the Navigation Channel Deepening via dredging component was determined to generate enough benefits, in light of the environmental and economic costs, to merit further evaluation. Four navigation channel dredging components, including a No Action component, were selected for detailed analysis.

Under the No Action component, no segments of the existing nine-foot navigation channel would be deepened. Dredging and new river training structures would not be required.

The three action components consist of deepening the existing navigation channel from 9 feet to 10, 11, or 12-feet, respectively. The MKARNS was divided into six river segments extending from the mouth near the Mississippi River to the Port of Catoosa in Oklahoma to assess the options of deepening the entire system or only specific segments. Each of the four components was considered for each river segment.

Additional dredging and river training structures (dikes and revetments) would be employed to achieve navigation depths between 10 and 12 feet. New dredged material disposal sites would be required to accommodate dredged material for each of the three action components.

Incremental deepening of only certain segments of the navigation system, such as only the lower segments, was determined not to be financially justified. Deepening the navigation channel to a depth of 10-feet also was not financially justified. The Corps' analysis indicated that the 11 and 12-foot components would achieve a positive cost:benefit ratio. These two channel deepening components were moved forward for development of project alternatives.

NAVIGATION CHANNEL MAINTENANCE FEATURE

The screening process included the evaluation of the four following components:

- Cessation of Maintenance Dredging;
- Maintenance Dredged Material Disposal via Transportation to Selected Approved Sites (*i.e.*, areas with high quality habitat would be avoided) in the Original Operation and Maintenance Plan;
- Maintenance Dredged Material Disposal at Approved Sites in the Original Operation and Maintenance Plan; and
- Maintenance Dredged Material Disposal at New Disposal Sites.

Cessation of maintenance dredging was not considered viable due to the inability to maintain a nine-foot navigation channel without maintenance dredging. Dredged material disposal via transportation to selected approved sites would involve movement of dredged material by barge or truck from places on the navigation system where disposal capacity has been reached to areas of low habitat quality where capacity remains. This component was not considered viable due to the lack of perceived benefits in light of the predicted economic costs.

The Maintenance Dredging and Disposal in Approved Areas component would involve movement of dredged material by barge or truck from places on the navigation system where disposal capacity has been reached to areas where capacity remains, regardless of the quality of habitat at the site. This component also would involve new river training structures, and was evaluated in more detail.

The Maintenance Dredging and Disposal at New Disposal Sites component would consist of disposal of dredged material at new sites not included in the original Operation and Maintenance Plan after existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable. This component also includes new river training structures, and was evaluated in more detail.

The two action components examined in detail were determined to be very similar financially. However, the Maintenance Dredging and Disposal at New Disposal Sites was the least environmentally damaging component. Only this component of the Navigation Channel Maintenance feature was retained for the development of project alternatives.

DEVELOPMENT OF ALTERNATIVES

Five project alternatives that consist of a combination of components from the three features were developed for further consideration and analysis.

- Alternative A – No Action: The existing flow management plan, navigation channel depth, and maintenance activities would remain unchanged.

- Alternative B – Navigation Channel Maintenance Only: The existing flow management plan and navigation channel depth would remain unchanged. Disposal of dredged material would occur at new sites not included in the original Operation and Maintenance Plan after existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable.

- Alternative C – Navigation Channel Maintenance and Operations Only Flow Management: The existing navigation channel depth would remain unchanged. Disposal of dredged material would occur at new sites not included in the original Operation and

Maintenance Plan after existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable. The existing flow management plan would be replaced with the Operations Only Flow Management Plan.

- Alternative D – Navigation Channel Maintenance, Operations Only Flow Management, and 11-Foot Navigation Channel: Disposal of dredged material would occur at new sites not included in the original Operation and Maintenance Plan after existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable. The existing flow management plan would be replaced with the Operations Only Flow Management Plan. The current 9-foot navigation channel would be deepened to an 11-foot navigation channel throughout the entire length of the MKARNS.

- Alternative E – Navigation Channel Maintenance, Operations Only Flow Management, and 12-Foot Navigation Channel: Disposal of dredged material would occur at new sites not included in the original Operation and Maintenance Plan after existing disposal sites reach holding capacity. New disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided where practicable. The existing flow management plan would be replaced with the Operations Only Flow Management Plan. The current 9-foot navigation channel would be deepened to a 12-foot navigation channel throughout the entire length of the MKARNS.

DESCRIPTION OF THE ALTERNATIVES EVALUATED AND A FEATURE DEVELOPED BY THE SERVICE

The plan recommended by the Corps is Alternative E. According to the analysis conducted by the Corps, this alternative maximizes national economic development (NED) benefits (has the greatest excess benefits over cost) according to the federal objective, and was therefore identified as the NED Plan.

The selected plan and a feature developed by the Service is briefly described here. The Corps draft Environmental Impact Statement (USACOE, 2005a) and Feasibility Report (USACOE, 2005b) provides a more detailed description of the selected plan.

A brief discussion of anticipated impacts for each project alternative is provided in the following section with emphasis on evaluation of Alternative E. Because Alternative E maximizes NED benefits consistent with the federal objective, the Corps has indicated Alternative E will be selected for implementation unless there are compelling reasons not to do so. Furthermore, Alternative E encompasses the features and components of all other alternatives (river flow management changes, channel deepening, and channel maintenance) and would have the most

significant impacts on the environment. A discussion of impacts anticipated to occur as a result of Alternative E, therefore, also would cover impacts anticipated to occur under the other alternatives.

ALTERNATIVE E: – NAVIGATION CHANNEL MAINTENANCE, OPERATIONS ONLY FLOW MANAGEMENT, AND 12-FOOT NAVIGATION CHANNEL

The Navigation Channel Deepening component of Alternative E would consist of deepening the current 9-foot navigation channel to a 12-foot navigation channel throughout the length of the MKARNS. The River Flow Management component would entail operating under the current plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench beginning at 3 percent lower system storage, except from June 15 through October 1. The Navigation Channel Maintenance component would consist of maintaining the navigation channel through dredging and river training structures; dredging sediment from the navigation channel in volumes consistent with current annual rates; disposal of dredged material associated with navigation channel maintenance in existing and new disposal sites not included in the original Operation and Maintenance Plan, after existing disposal sites reach holding capacity (new disposal sites would be selected based on the quality of the habitat type so that unnecessary impacts to forests, wetlands, and native grasslands could be avoided, where practicable); and the construction of river training structures and revetments. Alternative E would include the construction of 68 new dredged material disposal sites; 91 new and 142 modified river training structures; and 7 new and 13 modified revetments. A summation of the aspects of Alternative E that will cause impacts to fish and wildlife resources is provided in Tables 17 - 21.

The Corps conducted a hydrographic survey to locate areas along the channel that would require deepening. Pipe line dredges with cutter head equipment would be used to deepen the channel.

Construction of the terrestrial disposal sites would consist of excavating a pit and utilizing the excavated material to form a dike around the pit. The pits would include a discharge pit to return dredge water to the channel after settling. Submersible pumps would be used at pits where gravity or overland flow is not possible. The pits are designed to store twice as much as the initial channel dredging volume to allow for future operation and maintenance dredging. The design of terrestrial disposal sites can be found in the Dredge Disposal Site Sketches in Appendix C of the draft Feasibility Report (USACOE, 2005b).

Table 17. The difference in the number of days that river flows would exceed certain flow conditions at Van Buren, Arkansas, under Alternative E compared to existing conditions.

River Flow Management (change in days)		
At or above 60,000	At or above 100,000	At or above 137,000
-13.6	+1.7	0

Aquatic disposal areas would be created by installing a floating silt curtain around the disposal area to control the release of silt. Some open water disposal pits would be designed to provide

Table 18. Dredged material volumes by river segment and for Alternative E and the 11-foot channel depth for comparison.

	River Segment						
Navigation Channel Depth	Mouth to Pine Bluff (N. M. 0.0 –75.2)	Pine Bluff to Little Rock (N.M. 75.2-119.5)	Little Rock to Dardenelle (N.M.119.5-220.3)	Dardenelle to Ft. Smith (N.M.220.3-308.7)	Ft. Smith to Muskogee (N.M. 308.7-394.0)	Muskogee to Catoosa (N.M. 394.0-445.2)	**Total (cubic yards)**
No Action	0	0	0	0	0	0	0
11-foot depth	1,299,276	225,517	387,227	643,500	2,255,323	2,026,333	6,837,176
12-foot depth (Alternative E)	2,066,876	445,995	925,439	1,226,500	3,256,749	3,063,790	10,985,349

Table 19. Projected volume of dredged material and acres of both new and existing aquatic and terrestrial disposal sites for the Navigation Channel Deepening and Maintenance Features of Alternative E.

Dredge Volume (Cubic yards 000s)			**Dredge Area (Surface Acres)**			**Terrestrial Disposal Sites (Acres)**			**Aquatic Disposal Sites (Surface Acres)**		
Maint	**Deep**	**Total**	**Maint**	**Deep**	**Total**	**Maint Exist**	**Deep (New Only)**	**Total New**	**Maint Exist**	**Deep Exist**	**Total New**
						New		**Grand Total**	**New**	**New**	**Grand Total**
37,704	10,985	48,689	1,429	5,645	7,074	3,840	1,065	1,602	3,020	3,329	385
						537		5,442	148	237	6,734

Note: The Corps predicts that the same number and acres of aquatic and terrestrial disposal sites would be needed to deepen and maintain both an 11- and 12–foot navigation channel. The rate of fill, however, would differ due to the projected volume of dredged material required to obtain and maintain the two depths.

Table 20. New and modified river training dikes proposed to facilitate maintenance of the deeper navigation depth by river segment.

	River Segment					
	Mouth to Pine Bluff (N. M. 0.0 -75.2)	Pine Bluff to Little Rock (N.M. 75.2-119.5)	Little Rock to Dardenelle (N.M.119.5-220.3)	Dardenelle to Ft. Smith (N.M.220.3-308.7)	Ft. Smith to Muskogee (N.M. 308.7-394.0)	Muskogee to Catoosa (N.M. 394.0-445.2)
Existing Structures	278	201	392	236	195	12
New Structures Needed	4	30	5	6	44	0
Length of New Structures (ft.)	2,040	9,700	2,050	1,850	48,729	0
Number of raised or extended structures	36	4	31	24	0	0

Note: Structures required for the 11-foot channel component would be about 2/3 the length of those required for the 12-foot channel component.

Table 21. New and modified river training structures and revetments required for the Navigation Channel Deepening and Maintenance Features of Alternative E.

New River Training Structures			Modified River Training Structures			New Revetments			Modified Revetments		
Maint	Deep	Total	Maint	Deep	Total	Maint	Deep	Total	Maint	Deep	Total
2	89	91	50	92	142	2	5	7	4	9	13

Note: The same number of structures would be required for the 11-foot channel component. The structures would be about 2/3 the length of those required for the 12-foot channel component marsh habitat for fish and wildlife species. These open water disposal sites also would contain riprap breakwater dikes to protect the habitat created. The design of aquatic disposal sites can be found in the Dredge Disposal Site Sketches in Appendix C of the Corps draft Feasibility report (2005b).

Table 22. Impacts Matrix.

	Features of Proposed Navigation Project				
Impact	**Terrestrial Disposal of Dredged Material**	**Aquatic Disposal of Dredged Material**	**Dredging**	**Training Structure Modification/ Addition**	**Flow Management**
Negative effects to protected and sensitive species	X	X	X	X	X
Reduction in invertebrate biomass and diversity	X	X	X	X	X
Reduction of fisheries biomass and diversity		X	X	X	X
Loss of upland hardwoods and grasslands	X				
Loss of bottomland hardwoods	X				
Loss of wetlands	X	X		X	X
Reduction of gravel habitat			X		
Reduction of backwater habitat		X		X	X
Alteration of river hydrology and morphology		X	X	X	X
Reduction in water quality		X	X	X	X
Increased sedimentation and accretion		X	X	X	X
Increased flooding of riparian habitat		X			X
Resuspension/Exposure of contaminants from sediment	X	X	X		
Loss of large woody debris, aquatic vegetation, and shallows habitats		X	X	X	
Benefits to non-native and invasive species			X	X	X

ALTERNATIVE F: FISH AND WILDLIFE CONSERVATION INITIATIVE

The Service recommends that the Corps investigate the feasibility of adding a Fish and Wildlife Conservation feature to their existing alternatives. (We are not advocating the deepening of the navigation channel to a particular depth under this alternative.) We have provided a description of a conceptual Fish and Wildlife Conservation feature in the concept paper, " Arkansas River Navigation Project Mitigation Proposal and the Arkansas River Conservation Initiative." This concept paper is provided in Appendix C.

When implemented, calculation of the benefit-to-cost ratio should include the annual federal cost of implementing the initiative and the annual net benefits associated with the fish and wildlife and other outdoor-related recreational activities that are likely to increase in the project area (*e.g.,* hunting, fishing, photography, camping, hiking, etc.). We believe this alternative would serve to conserve important fish and wildlife resources for the benefit of the American people, while facilitating balanced development.

DESCRIPTION OF IMPACTS OF THE SELECTED PLAN

The selected alternative would result in significant impacts to important terrestrial and aquatic fish and wildlife resources. An impact matrix is provided in Table 22 to summarize the major impact types and demonstrate the relationship between the features of the selected plan and the anticipated impacts. We also provide a written description of anticipated impacts, by feature, below.

RIVER FLOW MANAGEMENT FEATURE

Based on an analysis of average annual pool levels and river flows, reservoir pool levels are expected to deviate only slightly from those observed under current operations.

Duration of storage between 0 and 10 feet above conservation pool changes slightly at all operational reservoirs with the exception of Copan, Kaw, and Hulah (Table 23). The greatest change, for example, is expected to occur at Tenkiller, Keystone, and Oologah reservoirs. At Lake Tenkiller, the reservoir pool elevation is expected to be two feet above the conservation pool elevation for four additional days per year as compared to existing conditions. At Keystone and Oologah, the conservation pool would be four feet above the current conservation pool elevation three additional days per year.

Table 23. Annual change in the number of days reservoirs are expected to be above conservation pool compared to existing conditions (No Action Alternative).

Alternative 4: Operations Only	0 feet	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet
Copan	0	0	0	0	0	0	0
Eufaula	1	0	0	0	0	0	0
Gibson	0	0	1	1	1	-2	-2
Grand	1	1	0	0	-1	0	0
Hudson	0	1	0	0	0	0	0
Hulah	0	0	0	0	0	0	0
Kaw	0	0	0	0	0	0	0
Keystone	1	2	3	2	2	0	0
Oologah	2	1	3	2	0	0	0
Tenkiller	2	4	2	1	1	0	0
Wister	1	1	0	0	0	0	0

Prolonged higher water levels during the growing season could adversely affect vegetation in portions of the conservation and flood control pools by drowning or weakening established plants not adapted for those hydrological conditions. Impacts would occur to both aquatic and terrestrial habitats. Although most bottomland hardwood trees are tolerant of flooding during the dormant season, intermittent inundation during the growing season may injure or kill trees (Black, 1980; Bell and Johnson, 1974; Hall and Smith, 1955). See Appendix D for data on reservoir pool elevations under existing conditions and with the recommended plan during the growing season, April – September.

Although average annual impacts at these reservoirs are expected to be minimal, it is important to note that the occurrence extreme conditions in even a single or a few consecutive years could significantly affect fish and wildlife resources. These effects are not likely to be evident from an analysis based on average annual reservoir levels and river flows. The effects would be dependent upon the time of the year in which inundation occurs, duration of inundation, and the elevation, soil characteristics, existing vegetation, and topography of the areas experiencing inundation. Impacts could include altering the littoral zone, altering or eliminating vegetated areas adjacent to the reservoirs, adversely impacting fish spawning and recruitment, and reducing available habitat for migrating birds, such as waterfowl.

Increased frequency and duration of flooding of agricultural lease lands on the WMAs also would decrease the value of the lease to farmers/lessees. The revenue gained from these lands, which is vital for continued operation and maintenance of the WMAs, would, in turn, decline. Farmers also likely would be less willing to plant wildlife food crops due to increased financial risks from flooding of crops.

Analysis of conditions that would occur in extreme high and low water years (rather than only on average annual lake levels and river flows) is more appropriate for considering potential effects to fish and wildlife resources. However, because water releases from each reservoir depend on numerous complex factors, such as weather conditions, water storage capacity, inflow rates, river flow rates downstream, power requirements, and navigation water requirements, accurately predicting the effects of the operating plan on fish and wildlife resources associated with the system reservoirs would be especially difficult. Predicting variables, such as weather patterns and power requirements, with complete accuracy, for example, is impossible. Long-term monitoring, consequently, would be necessary to accurately assess the impacts of changes in river flows and reservoir pool levels, as explained below in the section titled Discussion, Mitigation, and Recommendations.
The frequency of annual out-of-bank flows (*i.e.*, flows of 137,000 cfs or greater as measured at Van Buren) would not change from existing conditions. There would not be an increase in erosion potential or impacts to lower elevation wetlands and backwater areas over impacts currently occurring. River flow days above 175,000 cfs would, on average, increase only one day per year. Impacts to higher elevation wetland habitats also would not differ significantly from current conditions.

This alternative would, however, decrease the number of days per year for which flows would be greater than 61,000 cfs by 14 days. This would reduce the duration of flooding in the floodplain. Because the hydrology of wetlands in the floodplain would be altered, important wetland habitats may be adversely impacted.

River Flow Management: Summary Of Anticipated Impacts

Impacts anticipated from project implementation include:

- Increased inundation of portions of the flood control pools at the 11 controlling reservoirs in Oklahoma which may kill or injure vegetated areas adjacent to the reservoirs, alter the littoral zone, adversely impact fish spawning and recruitment, and reduce available habitat for migrating birds such as waterfowl;

- Increased frequency of flooding of agricultural lease lands which would decrease the value of the leases and their long-term revenue;

- Changes in the depth, temperature, turbidity, and velocity of the river downstream of each reservoir;

- Conversion of wetlands along the navigation system to agricultural production as a result of increased flood protection; and

- Increased potential for the accidental release of pollutants as a result of increased barge traffic.

NAVIGATION CHANNEL DEEPENING FEATURE

Under the proposed action, the entire 445 mile navigation channel would be maintained for a navigation depth of 12 feet. This would require dredging and/or construction or modification of channel training structures to deepen areas currently shallower than 12 feet. To achieve the desired navigation depth, many existing shoals would require in excess of 3 feet of substrate removal. Disposal of dredged material in Oklahoma would occur in both open water and terrestrial out of bank containment areas. In Arkansas, most of the disposal will occur in open water areas behind dike fields and revetments.
Early in the evaluation process, a multidisciplinary Multi-agency Ecosystem Evaluation Team was established to evaluate impacts of the proposed Navigation Channel Deepening feature on terrestrial habitats and ecological benefits resulting from proposed mitigation measures. The multidisciplinary team included various interests and technical expertise from the Little Rock and Tulsa Corps Districts, the Service, ERDC-EL, and Parsons, a private consulting firm. The team evaluated the environmental impacts of proposed dredging and disposal of dredged material using HEP analysis.

Terrestrial Resources

Dredging to achieve the 12-foot navigation depth would require numerous disposal areas along the navigation system in Arkansas and Oklahoma. The Service and ODWC worked closely with the Corps during the selection of new dredged material disposal sites to minimize and avoid impacts to high quality habitat such as bottomland hardwoods, native grasslands, and wetlands. The majority of the areas being impacted by dredged material disposal would be previously degraded habitats, such as agricultural lands and old field, thus minimizing direct impacts to higher quality terrestrial habitats. Wetlands and high quality bottomland hardwoods were avoided where possible.

Dredged material disposal would occur at 43 new terrestrial sites located within the floodplain of the Verdigris and Arkansas rivers. The existing terrestrial habitat would be lost due to the conversion of the site to a dredge spoil containment area (a pit surrounded by an earthen dike). Vegetation eventually would become established within the disposal pits. Willows, river birch, cottonwood, and a few species of sedges and grasses are likely to be early colonizers of the disposal pits (Allen and Hardy, 1980). However, the new community will generally be less diverse and have lower value to the terrestrial wildlife due to loss of terrestrial habitat, low plant species diversity and slow colonization by native plants (McMahon and Eckbald, 1975; Ziegler and Sohmer, 1977) and frequent disturbance over the project life due to disposal of dredged material.

The disposal of dredged material in terrestrial sites is expected to result in the conversion of about 1,602 acres along the MKARNS. The terrestrial dredge disposal sites in Arkansas would occur in cropland along the Arkansas Post Canal, which should reduce impacts to fish and wildlife habitat. Over the 50-year life of the project, the disposal of dredged material at terrestrial sites would result in the loss of about 15 acres of bottomland hardwood forest, 121 acres of upland forest, 300 acres of open field habitat, 315 acres of old field habitat, 790 acres of agricultural land, and 61 acres of barren/sand habitat.

Wetlands

National Wetland Inventory (NWI) maps were used to identify and help avoid wetland areas when choosing dredged material disposal sites. No impacts to wetlands are expected to occur. After currently utilized dredged material disposal sites reach their holding capacity, dredged material would be deposited in new disposal sites designated in the 2003 20-year Dredge Material Management Plan. Areas with high quality habitat, such as forest, wetlands, and high quality grassland, would be avoided for dredged material disposal wherever practical. This alternative would maintain the existing conditions, including the hydrology and species composition of wetlands.

The Service and our state partners were concerned during early planning stages of the study that channel incision could further eliminate floodplain hydrology causing loss of wetlands and seepage of water from adjacent oxbows. However, ERDC-EL evaluated sediment transport and flow models to assess the potential for channel incision and found no indication that this would result from channel deepening associated with this project (USACOE, 2005a).

Aquatic Resources

The navigation channel deepening feature would adversely affect important aquatic habitats and species. Backwaters, such as oxbows and dike fields, would be impacted as a result of dredged material disposal, construction and modification of river training structures, and sediment deposition. Gravel shoals would be removed by dredging. Freshwater mussels and fish would be impacted by dredging and disposal of dredged material.

Backwaters are essential to numerous species that are both ecologically and economically important to the system. Degradation and loss of backwater habitats would adversely impact numerous wildlife species. Some waterfowl (*e.g.*, mallard, wood duck) utilize backwater areas for roosting and feeding. Backwater areas also provide important feeding, breeding, and nursery habitat for reptiles (*e.g.*, river cooter, common snapping turtle), amphibians (*e.g*., leopard, chorus, cricket, and tree frogs), and invertebrates (*e.g.,* freshwater unionids).

Degradation and loss of backwater habitats also would adversely impact numerous species of fish. Species such as largemouth bass, crappie, catfish, and gar depend on backwater areas for foraging habitat and as nurseries (Buchanan, 1976). Loss of this habitat due to dredge spoil disposal, sedimentation, and revetments could substantially affect densities of these species and fish community structure. Largemouth bass are important predators within fish communities and are highly valued recreationally. Reductions in densities of largemouth bass would alter fish community structure and negatively affect the local economies related to recreational tourism.

In addition, many fish species once common to large river systems have experienced sharp population declines following impoundment and channelization (Gilbert 1992; Herkert 1992; Etnier and Starnes 1993; Pflieger 1997). For example, the alligator gar is now very rare in the Arkansas River (Buchanan, 1974 and 1976; Robinson and Buchanan, 1988). Many of these adversely impacted species relied on large backwater floodplains, floods, and uninhibited rivers.

Further loss of backwater habitat could adversely impact the alligator gar and other species dependent on backwater habitats.

Gravel substrates support a diverse array of fishes, many of which are obligate riverine species and sensitive to habitat degradation (Buchanan, 1976). Gravel bars provide important habitat for sturgeon, suckers, benthic minnows, madtoms, darters, and other species. For example, paddlefish, a species of concern in Oklahoma and Arkansas, migrate upstream to spawn over gravel bars in spring (Purkett, 1961; Wallus, 1986).

Loss of these habitats in similar navigation projects has demonstrated their importance to fish species and communities. Species such as paddlefish, shovelnose sturgeon, and numerous darters may be impacted by the loss of gravel substrates associated with dredging. Paddlefish are an ecologically important plankton foraging species and their roe has a high commercial value (Graham, 1997). This species is of particular concern due to the cumulative affects of dams inhibiting fish passage, loss of habitat from channelization, and commercial harvesting. Further loss of habitat could have dire consequences to this species within the Arkansas River system.

Additional sediment accretion and loss of surface waters will result from construction and modification of channel training structures, increased filling rates, and increased dredged material disposal. This will increase the rate of habitat loss and add to the cumulative loss of fisheries backwater habitat, side channels, and islands due to land bridging that has occurred since the initial project completion.

The effects of the deepening feature on the hydrologic and geomorphic characteristics of the Arkansas River ecosystem have not been fully assessed. ERDC-EL conducted a geomorphic assessment to evaluate potential project impacts (USACOE, 2005a). However, as indicate in the Corps report, the results should be considered preliminary due to data limitations of the model. The long-term impacts could be substantial, and would require further study to more accurately ascertain the impacts. For example, over the project life, unanticipated deepening and scouring of the channel during high flow periods could eliminate remaining gravel shoals, an essential habitat component for numerous aquatic species, as discussed above.

Increases in dredging and barge traffic could have additional deleterious effects, including entrainment of aquatic species in the dredge cutter head (Reine and Clark., 1998), increased fish passage through dams, and increased zebra mussel and other invasive species immigration. Fish and mussel entrainment currently occurs with existing maintenance dredging; however, this project would require substantially more initial dredging in addition to long-term maintenance dredging, that will in turn increase the amount of entrainment. While increasing the passage of fish through dams is usually encouraged, in some circumstances increasing passage of non-native or invasive species can have serious consequences. Paddlefish, freshwater eels, alligator gar, sturgeon, and numerous other species likely would benefit from increased passage through locks. However, increased lockage also would allow further introduction and/or immigration of non-native and invasive species, such as zebra mussels, big head carp, and yellow bass. The additional lockage would increase the likelihood of non-native introductions upstream of locks and dams and enhance the ability for species like zebra mussels to maintain high densities.

Waves created by the wakes of more numerous and deeper draft barges could increase the volume and rate of bank failure and subsequent erosion along the river. Currently, waves caused by barges, recreational boats, and wind blowing across wide pools contribute to bank failures and erosion. Increasing the volume and frequency of waves due to barge traffic could exacerbate the extent and rate of bank failure and erosion, further contributing to cumulative losses of riparian and aquatic habitat within the system.

Aquatic Disposal Sites

The multidisciplinary team collectively evaluated the environmental impacts of the proposed dredging and disposal on the MKARNS through HEP analysis. The HEP analysis was used to determine impacts on aquatic habitats and ecological benefits resulting from the proposed mitigation. According to GIS data compiled by the Corps, dredged material would be deposited on approximately 3,020 acres of existing aquatic maintenance dredged disposal sites in Arkansas during continued operation of the navigation system. Under the channel deepening feature of Alternative E, aquatic disposal would occur on an additional 148 acres of aquatic habitat for maintenance dredging, 3,329 acres of shallow water dike field habitat in Arkansas and 237 acres of aquatic habitat in Oklahoma for a total of 6,734 acres. Approximately 5,645 acres and 10,985,340 cy of navigation channel substrate would be dredged for deepening along the MKARNS. In addition, approximately 1,429 acres and 37,704,000 cy of substrate would be dredged for maintenance along the MKARNS for this alternative for a total of 6,238 acres and 44,541,000 cy. Additionally, construction of 92 new and modification of 89 existing river training structures, and the additional 5 new and modification of 9 existing revetments is proposed for this project (USACOE, 2005a).

Because the main channel of the MKARNS currently has numerous training structures and has been previously degraded through establishing and maintaining the navigation channel, prime aquatic substrate habitat loss due to maintaining and deepening the channel to 12 feet, and from adding and modifying river training structures, would be quantitatively less than if the river were in a natural state. However, the cumulative loss of habitat from this system only increases the qualitative value of the remaining habitat.

Gravel Bars

Estimates of the total available acres of gravel substrate along the project length were 6,984 acres. Gravel surveys found 165 acres of gravel and 620 acres of sand/gravel mix substrate in proposed dredging areas that would be impacted by the project (Table 24).

Freshwater Mussels

A freshwater mussel survey was conducted by Ecological Specialists, Inc., (ESI) during September, October and December 2004. The new surveys by ESI found no federally-listed or proposed threatened or endangered species within the MKARNS, but did find productive, diverse (29 species total) mussel communities within most reaches of the system.

Table 24. Location and area of gravel and sand/gravel mix substrates in the Arkansas River Navigation Project. All locations coincide with proposed dredging sites for the 11 and 12-ft channel.

Pool	River Mile	Gravel (acres)	Total per pool	Mix sand/gravel (acres)	Total per pool
	108	1.6		7.47	
Pool 5			1.6		7.47
	140	0.11		4.94	
	146	3.42		36.45	
Pool 7	150	17.44		36.88	
	150.5	20.43		1.4	
			41.4		79.67
	186	23.36		144.25	
Pool 9	205	27.8		6.77	
			51.16		151.02
Pool	229	0.61		54.15	
10			0.61		54.15
Pool	361	36.7		154.15	
15					154.15
	374	1.23		55.81	
Pool	393	0.83		41.06	
16	395	3.54		32.93	
			5.6		129.8
	402	7.24		32.14	
Pool	421	20.69		11.82	
17			27.93		43.96
Total		**165**		**620.22**	

The proposed project would impact mussels and mussel habitats, most directly by dredging and disposal of dredged materials in conjunction with constructing a minimum 12-foot channel depth. The potential exists not only for direct removal and burial of mussels, but also for effects on nearby mussels from dispersion of temporarily suspended sediments and destabilization of substrates adjacent to the excavated channel. In addition, the expected operation of larger barges in the MKARNS would increase re-suspension of sediments and other turbulence-related effects in the system (Sparks *et al.,* 1980).

The largest impact to freshwater mussels would occur as a result of dredging impacts to beds found in the Arkansas Post Canal. Recent survey efforts indicate about 2 million mussels may occur in the canal (Ecological Specialists, 2005). The estimate is based on qualitative sampling (41 five minute samples) and there may be considerable variability in the number of mussels present (Ecological Specialists, 2005). Additional mussel concentrations would be impacted by the project. Ecological Specialists (2005) provided specific information on other mussel concentrations that would be affected by proposed dredging and disposal activity. This report can be found in the draft Environmental Impact Statement for the Arkansas River Navigation Study (USACOE, 2005a).

Water Quality and Sediment Analysis

Deepening the channel, constructing or modifying training structures, and increasing the channel volume could concentrate flows and increase the instability of channel substrates. This could result in increased turbidity, oxygen reduction, channel incision, bank failure, headcutting, and backwater sediment deposition. Increased turbidity would affect reproduction of some fish and mussel species, reduce primary productivity, impact foraging, and alter water quality. The construction and modification of new river training structures would have a short-term minor adverse impact on surface water as sediment suspension may increase during construction.

Channel incision, bank failure, and head cutting would contribute to additional habitat loss, suspension of sediments, and sediment accretion in dike fields. Channel incision further eliminates floodplain hydrology causing loss of wetlands and seepage of water from adjacent oxbows. Hydrologic and morphologic modeling of flows and substrates suggest that velocities and water elevations should not cause long-term channel instability that would result in incision or tributary headcutting (USACOE, 2005a). However, these results should be considered preliminary due to the data limitations of the model and lack of prototype information (DEIS Appendix C.8 Geomorphic Assessment). Long-term monitoring should be performed to validate the predictive capability of these models.

Dredging conducted to achieve a 12-foot channel would require the removal of approximately 10,985,340 cy above the volume of material removed by maintenance dredging, which could negatively affect water quality within the MKARNS if any contaminants occur within riverbed sediments. Release and resuspension of contaminants into the water that have been accumulating in sediments for many years could have toxic effects to both aquatic and terrestrial species along the Arkansas River. Additionally, contaminants could be introduced into backwater or adjacent terrestrial habitats through dredge disposal sites.

The Corps conducted a limited sediment analysis along the MKARNS during September 2004 and February 2005. The results of the sediment sampling can be found in Appendix E of the DEIS (USACOE, 2005a). Results of the sediment sampling suggest that the composition and extent of contaminants currently trapped in sediments from Arkansas and Oklahoma are insufficient to cause concern. An Inland Testing Manual Tier I evaluation would be performed along watercourses before dredging is conducted. The Service's comment and recommendation letter regarding the Oklahoma portion of the sediment analysis is provided in Appendix E of this report.

The ODWC has specific concerns regarding dredging activities and sediment analysis within the vicinity of the Sequoyah Fuels Corporation Industrial site located in Gore, Oklahoma. Their comments and recommendations can be found in their concurrence letter in Appendix A.

Increased dredging and barge traffic likely would lead to increased turbidity and sediment deposition (Sparks *et al*., 1980). These impacts would further contribute to the poor water quality that currently is observed during late summer and fall in the lower ends of pools and in tailwater releases. Low dissolved oxygen concentrations and high nutrient levels often exceed current state water quality standards. Increasing the volume and rate of deposition,

sedimentation, and nutrient transport will contribute to further water quality degradation and impacts to aquatic communities.

NAVIGATION CHANNEL DEEPENING: SUMMARY OF ANTICIPATED IMPACTS

Accurately identifying the nature and magnitude of anticipated impacts is difficult to impossible given the limited amount of data available. Further study prior to project implementation and initiation of long-term monitoring studies would be required to more precisely describe the various impacts that would occur due to deepening the navigation channel. Potential impacts anticipated as a result of this project are provided in Table 22 and summarized below.

- Numerous protected and sensitive species may be affected by this project; however, through long-term monitoring, adaptive management, mitigation, and conservation these species can be protected and preserved;

- Many freshwater mussels and beds throughout the system will be affected either directly by dredging and dredged material disposal or indirectly by increased turbidity and sedimentation;

- Numerous species of fish and associated fish community structure could be affected by additional loss of gravel and backwater habitats associated with dredging and dredges material disposal;

- Various types of terrestrial habitats would be impacted by dredged material disposal;

- Wetlands would be impacted by dredge spoil disposal, sediment deposition, and hydrologic alteration;

- Reduction of gravel and sand shoal habitats would impact important habitat for fish spawning, foraging, and reproduction;

- Loss of backwater and adjacent terrestrial habitat would occur with dredged material disposal;

- Changes in water depth, temperature, turbidity, and velocity of the river downstream of each reservoir would occur;

- An increase in the sediment deposition rate in backwaters, shallows, side channels, and dike fields;

- A reduction in the habitat value of backwater areas, such as oxbow lakes and sloughs, that provide important waterfowl and fish spawning habitat for a variety of species;

- Large woody debris, aquatic vegetation, and vegetated shallows may be further lost to sediment deposition in back waters and side channels; however, these habitats may be conserved or restored through project design and mitigation;

- Impacts to additional lands and habitats will continue and increase;
- Increased potential for the accidental release of pollutants as a result of increased barge traffic.
- Geomorphological changes, such as channel incision, bank failure, headcutting, and scouring are not likely to occur, but should be monitored;
- Increased habitat loss and erosion from bank failures caused by increased barge wake frequency and magnitude;
- Water quality degradation in lower pools and tailwaters from increased sedimentation, turbidity, and deposition, resulting in increased nutrient loading and dissolved oxygen depletion;
- Increased fish entrainment during dredging; and
- Increased non-native and invasive species passage through locks and dams.

Navigation Channel Maintenance Feature

Although smaller volumes of material would be removed more frequently, impacts anticipated from recurring maintenance of the navigation channel depth would generally be the same as those anticipated from the proposed navigation channel deepening feature described in the preceding section. Adverse impacts would occur due to the loss of both terrestrial and aquatic habitats as a result of dredging activities, construction of river training structures, and disposal of dredged material.

DISCUSSION, MITIGATION, AND RECOMMENDATIONS

The Service's overall mitigation goal is to protect and/or enhance important fish and wildlife resources while facilitating balanced development. The Service's Mitigation Policy (*Federal Register* 46(15):7644-7663) provides guidance for formulating measures to avoid, reduce and offset environmental impacts. These guidelines follow the sequenced approach to mitigation presented in the Council on Environmental Quality's National Environmental Policy Act (NEPA) regulations (40 CFR 1508.20). The mitigation definition found in the NEPA regulations consists of five sequential steps: 1) avoiding the impact altogether by not taking a certain action or parts of an action; 2) minimizing impacts by limiting the degree or magnitude of the action; 3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and 5) compensating for the unavoidable impacts by replacing or providing substitute resources or environments. The primary focus of the Service's Mitigation Policy is mitigation of losses in habitat value, with the degree of mitigation corresponding to the value and scarcity of impacted habitats.

CATEGORIZATION OF FISH AND WILDLIFE HABITATS

Fish and wildlife resources have been categorized in accordance with the Service's Mitigation Policy. Category 2 resources, as defined in the policy, include high quality habitats that are scarce or becoming scarce in the ecoregion or nationwide. Habitats considered category 2 resources within the project area are high quality native prairies, caves, streams (mountain), submerged gravel bars, oxbow lakes and river cuttoffs, bottomland hardwood forests, riparian forests, and other high quality palustrine and lacustrine wetlands, such as river swamp forests. The mitigation goal for this category is no net loss of in-kind habitat value. Section 906(d) of WRDA 1986 also requires that mitigation for impacts to bottomland hardwood forests be in-kind, to the extent possible.

Areas of somewhat lesser quality riparian forests, upland forests, prairies, the Arkansas River proper and its associated tributaries and delta streams, man-made wetlands and reservoirs are assigned to category 3. Category 3 resources include habitat of high to medium value that is abundant on a national basis. The preferred mitigation goal for category 3 habitat is no net loss of habitat value while minimizing loss of in-kind habitat value. Mitigation in-kind for category 3 resources is preferred, but out-of-kind mitigation with no net loss of habitat value is acceptable. The Service's Mitigation Policy is used as a basis for both our impact analyses and in development of conservation recommendations and measures.

FISH AND WILDLIFE MITIGATION MEASURES

River Flow Management Feature

Based on average annual lake levels and river flows, reservoir level fluctuations are expected to change only slightly from current operations. The biological change resulting from implementation of the selected alternative at the controlling reservoirs, as indicated by average water level conditions, would not constitute a significant adverse impact for which mitigation would be required.

The Service believes, however, that in order to fully address potential impacts to fish and wildlife resources at the 11 Oklahoma reservoirs, extreme conditions that could occur during high and low water years also must be considered. As discussed previously, the conditions that occur during extreme high and low years could significantly affect fish and wildlife resources. These effects are not likely to be evident from an analysis based on average annual reservoir levels and stream flows. The effects of changes to the resulting reservoir pool levels would be dependent upon the time of the year in which they occur, duration of inundation, and the elevation, soil characteristics, existing vegetation, and topography of the areas experiencing inundation. Impacts could include altering the littoral zone, killing or injuring vegetated areas adjacent to the reservoirs, adversely impacting fish spawning and recruitment, and reducing available habitat for migratory birds.

Water releases from each reservoir depend on numerous, complex factors such as weather conditions, water storage capacity, inflow rates, river flow rates downstream, hydropower

generation requirements, and navigation water demands. Accurately predicting the effects of the proposed operating plan on the fish and wildlife resources downstream of the reservoirs on the system would be especially difficult. For example, weather patterns which ultimately influence fluctuations in river flow and reservoir pool elevations cannot be predicted with complete accuracy. However, operational changes superimposed upon hydrologic data from a period of record can provide meaningful insight into potential impacts to natural resources.

Uncertainty is an unavoidable component of managing and maintaining the natural resources associated with the system. Unexpected detrimental events are likely to occur. These events will alter fish and wildlife resource values associated with this large and dynamic system.

We believe that the mitigation goal for the fish and wildlife resources associated with the 11 primary flow modifying reservoirs in Oklahoma likely could be met through pro-active conservation actions and monitoring. Therefore, to avoid and minimize potential adverse effects as a result of the Corps recommended River Flow Management feature, and to provide appropriate compensation, the Service recommends that the Corps:

- Incorporate minimum instream flow releases for each reservoir into the selected plan (Orth and Maughan, 1981);
- Conduct angler surveys for a minimum period of five years after the plan has been implemented to assess economic impacts;
- Implement a monitoring program to assess realized impacts to the littoral zones and vegetated areas adjacent to the reservoirs, including the WMAs and agricultural leases managed by the ODWC, at each of the 11 controlling reservoirs in Oklahoma;
- Assess the impacts of the plan on dissolved oxygen concentrations and stream morphology in the rivers below the dams; and
- Develop and implement lake level management plans for the 11 Oklahoma reservoirs, where feasible, to enhance the fishery resources and the migratory bird habitat of these areas.

The lake level management plans should be designed to ensure that unnecessary negative impacts to aquatic fish and wildlife habitat due to seasonal fluctuations in conservation pools are avoided and/or minimized to the greatest extent practicable. We recommend determining, in cooperation with the Service and the ODWC, the most appropriate rule curve management for each reservoir to enhance fish and waterfowl populations. Shallow water habitat that provides spawning and nursery habitat for fish should be made available by making every reasonable effort at holding reservoir pool levels relatively stable during the fish spawning season. Slight seasonal draw downs in summer and early fall would provide areas to seed waterfowl food plants, such as millet or sorghum, on suitable exposed mudflats around the reservoirs and would facilitate the natural establishment of wetland vegetation. Flooding these areas during late fall then would provide foraging habitat for wintering waterfowl. The Service's Waterfowl Management Handbook (USFWS, Fish and Wildlife Leaflet 13) provides a single source of information regarding the management of waterfowl and their habitat. This handbook is

available as a series of chapters and can be accessed at the following website: <http://www.nwrc.usgs.gov/wdb/pub/wmh/preface.html>.

Implementation of the selected plan would reduce the duration of flooding in the floodplain. Because the hydrology of floodplain wetlands would be altered, important wetland habitats may be adversely impacted. Unfortunately, sufficient information to determine the extent of those impacts is lacking. In order to adequately assess impacts to these wetlands and to compensate for any unavoidable losses, we recommend that the Corps:

- Identify the specific lands that would receive flood protection benefits;
- Determine the quantity (acres) and quality (habitat type and value) of wetlands that the selected operating plan would alter;
- Obtain conservation easements in floodplain areas that would be protected from flooding to deter floodplain development;
- Determine the quantity (acres) and quality (habitat type and value) of wetlands that should be acquired and/or managed to compensate for wetland losses; and
- Provide compensatory mitigation for any unavoidable wetland impacts.

Navigation Channel Deepening and Maintenance Features

Dredging and disposal of sediments would be necessary to achieve and maintain a 12-foot navigation channel. These actions would have substantial direct and indirect effects to both the aquatic and terrestrial sites in which they would occur. Impacts anticipated from deepening and maintaining the proposed navigation channel depth would occur as a result of losses to both aquatic habitat, due to dredging and construction of river training structures, and to terrestrial habitat due to disposal of dredged material. Because the impacts of maintaining the navigation channel depth generally would be similar in nature as those anticipated from the proposed navigation deepening feature, we discuss mitigation recommendations for these project features together.

Presently the interagency evaluation team has completed the impact assessment for the terrestrial disposal sites in Oklahoma. Unfortunately, the team does not have complete assessments for in-stream dredged material disposal sites in Oklahoma or Arkansas. There is great potential for this action to substantially and continually impact the habitat and species along and within the Arkansas River ecosystem. We anticipate substantial direct and indirect effects to both the aquatic and terrestrial sites in which they will occur.

Terrestrial Resources

The Service, Corps, and ODWC worked cooperatively during the planning process to avoid unnecessary impacts to high quality fish and wildlife habitat. Potential disposal sites were either relocated or reconfigured during project planning stages in order to avoid impacts to bottomland hardwoods, wetlands, and high quality floodplain forest.

For example, four of the 43 originally proposed dredged material disposal sites in Oklahoma were proposed to be located on lands licensed to the State for fish and wildlife management. Disposal of dredged material on these sites would have directly impacted about 109 acres of land in the Choteau and Webbers Falls units of the McClellan-Kerr WMA, which largely consist of bottomland habitat along the channel and scattered agricultural fields.

The HEP models and data provided by the interagency team were used by ERDC-EL to evaluate impacts from dredged material disposal and determine mitigation needs. Out of bank disposal of dredged material in Oklahoma is expected to result in the loss of 220 acres of old field grassland and 170 acres of open field grassland over the 50-year project life. Fifteen acres of bottomland hardwood forest and 287 acres of floodplain forest also are anticipated to be lost with the proposed project over the 50-year project life. Most of the forested acres expected to be lost is an artifact of the natural succession of many old field sites along the navigation system to early forest stages over the project life.

A plan for mitigating unavoidable terrestrial disposal impacts in Oklahoma was developed through interagency cooperation by biologists with the Corps, Service, and the ODWC. The proposed mitigation plan was developed in accordance with the Service's Mitigation Policy with the primary focus on concerns for potential habitat value losses. The plan was developed to ensure that losses, as measured in habitat value, rather than in acres, would be offset over the 50-year project life.

The compensatory mitigation plan currently endorsed by the Service and ODWC consists of bottomland hardwood restoration and marsh creation at two sites along the Verdigris River that currently are agricultural fields: OK 405.0 and OK 408.9 (Figure 3). The proposed mitigation plan would consist of a total of 248 acres of marsh creation and 130 acres of bottomland hardwood restoration. Recommended compensatory mitigation at the site near river mile 405.0 would consist of 157 acres of marsh creation and 61 acres of bottomland hardwood restoration. Recommended compensatory mitigation measures at the site near river mile 408.9 would consist of about 91 acres of marsh creation and about 69 acres of bottomland hardwood restoration. The restored bottomland hardwood forests and marsh wetlands would compensate for impacts associated with disposal of dredged material on terrestrial sites. Although the number of acres restored would be less than the acres impacted, the quality of habitat anticipated to be gained through this mitigation plan (HSI range 0.7 – 0.75) is much higher than that lost through disposal of dredged material (HSI range 0.28 – 0.50). This plan should completely offset losses of habitat

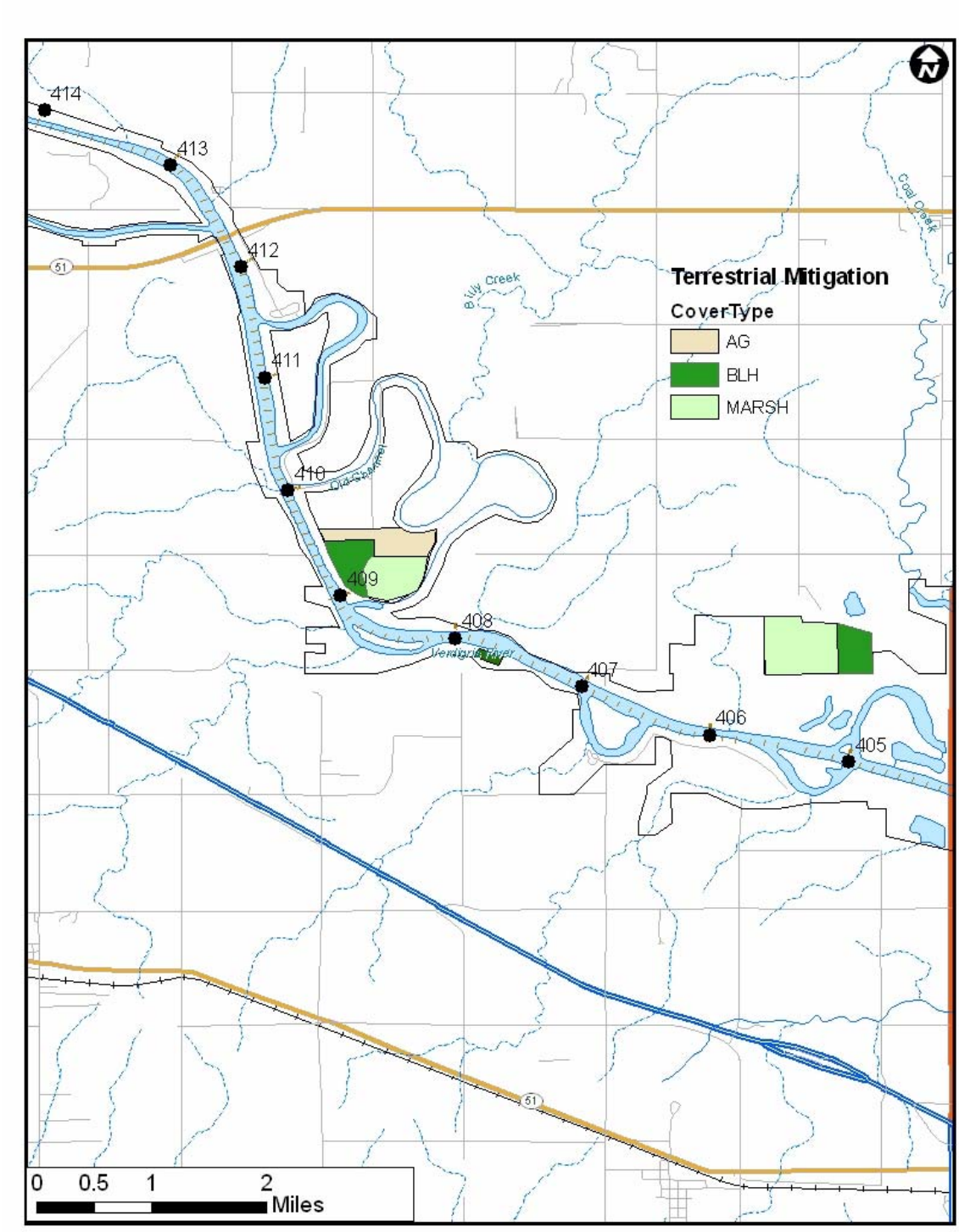

Figure 3. The terrestrial compensatory mitigation plan currently endorsed by the Service and ODWC consists of bottomland hardwood restoration and marsh creation at two sites along the Verdigris River that currently are agricultural fields.value over the 50-year project life that would occur as a result of terrestrial disposal of dredged material in Oklahoma (Tables 25, 26, and 27).

Appendix F provides additional preliminary recommendations pertaining to tree plantings, monitoring, and remedial actions for bottomland hardwood restoration. We recommend developing detailed restoration, monitoring, and contingency plans through interagency coordination for both the bottomland hardwood and marsh wetlandrestoration sites. The resource agencies should be afforded the opportunity to review the final mitigation plan prior to implementation.

Dredged material disposal sites OK 379.1 L-DI and OK 389.7 L-DI occur on land allocated to the ODWC for fish and wildlife resource management. These lands are currently in agricultural leases. The ODWC utilizes revenue gained from agricultural leases to support management activities on WMA lands. Construction of dredged material disposal pits at these locations would result in the loss of 80 acres of WMA lands currently in agricultural leases and the important revenue gained from these leases. Because agricultural land used as food plots is assumed to have a constant HSI value of 0.24 throughout the project life, recommended compensatory mitigation for this impact is to replace this land at a 1:1 acre ratio with agricultural land adjacent to the recommended mitigation sites (Figure 2).

Table 25. Summary of terrestrial acres and AAHUs anticipated to be lost as a result of the selected plan.

	Bottomland Hardwoods	**Upland Forest**	**Forest Total**	**Old Field**	**Open Field**	**Grassland Total**
Sum of Acres Lost	-15	-287	-302	-220	-170	-390
Sum of AAHUs Lost	-7.3	-76.4	-83.7	-123.8	-71.0	-194.0
Average Annual HSI Value			0.28			0.50

Table 26. Summary of terrestrial habitat acres and AAHUs anticipated to be gained as a result of the recommended mitigation plan for unavoidable impacts to terrestrial resources.

Mitigation Site	**Bottomland Hardwoods**			**Marsh**		
	Acres gained	**Net AAHUs Gained**	**HSI Value of Mitigation Sites**	**Acres Gained**	**Net AAHUs Gained**	**HSI Value of Mitigation Sites**
408.9	69	48.3		91	66.6	
405.0	61	42.7		157	131.3	
Total	130	91.0	0.7	248	197.9	0.75

Table 27. Summary of the Net Loss and Gain of AAHUs anticipated as a result of the selected alternative and the recommended terrestrial mitigation plan.

Compensatory Mitigation for Forest Impacts Anticipated to be Realized through Bottomland Hardwood Restoration		**Compensatory Mitigation for Grassland Impacts Anticipated to be Realized through Marsh Restoration**		**Compensatory Mitigation for Grassland Impacts Anticipated to be Realized through Bottomland Hardwood Restoration**	
Bottomland and Upland Forest AAHUs loss	-83.7	**Grassland AAHUs Loss**	-194.0	**Carry over AAHUs from BLH gain**	+7.3
Bottomlnad Hardwood AAHUs Gain	+91.0	**Marsh AAHUs Gain**	+187.0	**Deficit AAHUs for Grassland Impacts after Marsh Benefits Applied**	-7.0
Net Gain or Loss	+7.3	**Net AAHUs Gain or Loss**	-7.0	**Surplus of AAHUs after Net Bonus BLH AAHUs Applied**	+0.3

Eight additional sites were selected by the interagency team for which appropriate mitigation measures likely could be developed to improve habitat value and offset losses, such as river cutoffs and oxbows along the Verdigris River (Table 28). The Service has repeatedly sought conservation for the oxbows because they represented some of the most valuable habitat remaining after the original construction of the navigation system. Additional potential mitigation features and sites also were identified in the Service's planning assistance letter dated June 15, 2004. More information pertaining to additional mitigation sites, including locations and potential AAHUs, also can be found in the HEP Appendix of the Corp's draft Environmental Impact Statement for ARNS. Alternative mitigation plans would be acceptable to the Service and ODWC provided that the plan was 1) developed through interagency coordination, and 2) demonstrated through a HEP or similar analysis to completely offset losses in habitat value over the project life.

Table 28. Potential mitigation sites for unavoidable impacts to terrestrial resources as a result of disposal of dredged material in the floodplain.

Potential Mitigation Area by River Mile	River Bank	Bottomland Hardwood Restoration (acres)	Marsh Wetland Restoration/Creation (acres)
406.0	Left	162	38
408.9	Left	69	91
405.0	Left	61	157
410.4	Left	124	46
412.4	Right	570	224
415.2	Right	626	500
410.11	Left	106	38
419.5	Left	1,074	176
420.5	Left	140	44
422.8	Right	332	70
379.1	Left	40	0
379.1 Alternative	Left	0	40
389.7	Left	40	0
389.7 Alternative	Left	0	40

Maintaining the habitat value of compensatory mitigation lands likely would require on-going maintenance and management efforts. Without these efforts, the habitat value of the lands is likely to decrease and fail to meet mitigation projection goals. Losses in habitat value as a result of the project, therefore, would not be offset by appropriate mitigation without ongoing maintenance and management. In accordance with section 2 (d) of the FWCA, costs to carry out fish and wildlife conservation measures are to be considered project costs. Furthermore, section 906 (c) WRDA 1986 states that the costs of fish and wildlife mitigation are to be cost-shared at the same rate as the project purpose causing the impact. Navigation projects are fully federally-funded. The Corps should seek full congressional funding for Operation and Maintenance (O and M) needs. These funds should be provided to the managing entity on an annual basis. An O and M budget should be developed in cooperation with the managing entity prior to project implementation.

Aquatic Resources

Deepening the navigation channel would have significant adverse impacts on aquatic fish and wildlife resources. The primary impacts would include the loss of back water and side channel aquatic habitat due to dredging, dredged material disposal in aquatic sites and the construction and raising of river training structures; the removal and alteration of gravel bars through dredging; and direct adverse effects on freshwater mussel patches and beds *(i.e.,* mussel concentrations) due to dredging activity and the disposal of dredged material.

Additional impacts to important aquatic fish and wildlife resources are certain to occur as a result of the proposed plan, including impacts to water quality, re-suspension of contaminants in

dredged areas, impacts to mussel concentrations near dredging and disposal areas, and incision and headcutting in tributary streams. However, an adequate assessment of these types of impacts cannot presently be conducted and will require long-term monitoring. Our recommendations for long-term monitoring can be found in the "Environmental Management Program" section below.

The impacts to aquatic fish and wildlife resources anticipated as a result of disposal of dredged material in dike fields and backwater areas, and the construction/modification of river training structures, are being evaluated using HEP. The Corps, Service, ODWC, and AGFC have been in constant and frequent coordination regarding the assessment of impacts the navigation channel deepening would have on aquatic fish and wildlife resources. The ERDC-EL is using HEP to determine aquatic impacts and necessary mitigation features using data provided by the interagency team. Unfortunately, due to the extremely expedited schedule for this study, the aquatic impacts analysis has not been completed as of the date of this report.

The Service understands that the Corps intends to fully mitigate for aquatic resource impacts. The Service is willing to continue coordination with the Corps and our State partners to assist in the analysis and development of an appropriate aquatic resource mitigation plan that would ensure aquatic resource impacts would be offset. The following sections discuss the need for fish and wildlife mitigation measures, discuss the current status of the impacts analysis, and recommend measures that would avoid, minimize, and compensate for anticipated project impacts.

Aquatic Resources: Aquatic Disposal Sites and River Training Structures

Disposal of dredged material in backwater habitats will have significant adverse impacts to aquatic fish and wildlife resources. The rate and extent of loss of backwater areas will increase as a result of increased sedimentation from dredged material disposal and deposition associated with this project. Results from the aquatic habitat impacts analysis illustrate a positive relationship between fish abundance and the depth of dike pools. This implies that reducing water depth in a dike field through dredged material disposal and new training structure construction and modifications would have a major adverse impact to fishes. However, high quality habitat could be avoided, thereby minimizing the impact of this action.

There has been an ongoing effort to restore and maintain many backwater areas in Arkansas through dike notching to facilitate removal of accreted sediments. Additional dredged material disposal in these areas would contribute to the cumulative loss of habitat and the overall degradation of fish and wildlife resources within the MKARNS.

Careful planning prior to open water disposal, however, could provide opportunities to enhance and/or create important fish and wildlife habitat. Areas that already provide high quality habitat, such as backwater channels and oxbows, should not be considered for the disposal of dredged material. Dredged material also could be used to create, rebuild, or enhance island and/or marsh habitat in existing areas of low habitat quality.

Island creation or enhancement generally requires the disposal of suitable dredged material on existing islands or in shallow water areas. Although substrate preferences vary by target species, coarse material generally should be used in island creation or enhancement due to its greater stability. The elevation of created islands should be high enough to minimize flooding of nesting areas, but low enough to minimize excessive wind erosion. Generally, islands that provide the highest benefits for wildlife have similar characteristics. These islands tend to: 1) be separated from the mainland a sufficient distance or with a surrounding water depth of about 1.5 - 2 feet to provide relatively predator-free nest sites, 2) have a high ratio of water edge to land mass, and 3) be in close proximity to loafing sites and food sources.

Marsh habitat development would consist of utilizing the dredged material to change a deep water area into a shallow water wetland. Achieving the desired elevation requires detailed management of the quantity and configuration of dredged material disposed at the site.

The guidelines and criteria followed for a particular habitat development/creation project ultimately should be based on the target species for which the habitat is being created. For example, islands created specifically for interior least tern nesting habitat should be separated from the mainland to reduce access by predators. The portion of the island above the water surface should be capped with a sandy substrate. A vegetation management program designed to control vegetation would be necessary to ensure appropriate nesting requirements are met over the project life.

The Service's "Resource Publication 149: Mitigation and Enhancement Techniques for the Upper Mississippi River System and Other Large River Systems" (Schnick *et al*., 1982) provides valuable information on the use of dredged material to develop high quality island and marsh habitat. This information includes guidelines, disposal techniques, required equipment and materials, and references to many other important scientific papers and reports concerning the use of dredged material to enhance or create habitat.

Additionally, the Sandtown Bottoms area along the Arkansas River and within the Sequoyah NWR has experienced heavy shoreline erosion due to wind-driven wave action, river current erosion, and boat/barge traffic. The Service recommends that the Corps investigate the feasibility of using dredged material and structures, such as geo-tubes, in order to: a) provide long-term erosion control, b) provide a substrate for riparian vegetation establishment, and c) increase the aesthetic value of the area. The use of such structures would restore wildlife habitat value to the area by facilitating the development of riparian vegetation and, thereby, contributing to the environmental quality of the refuge's natural resources. We believe that dredged material could be used as fill for the tubes. The use of dredged material as bank stabilization material would sufficiently minimize shoreline erosion due to ongoing and future operations of the MKARNS.

Numerous dike fields currently occur along the navigation system and many new dikes would be constructed or modified as part of the proposed project. These structures will be used to guide the river and maintain the navigation channel. Adding notches to rock dikes would increase the habitat quality and diversity of dike fields and allow the dikes to continue to provide their

navigation function. The river would be allowed to move in and out between the notches, while sediment build up would likely result in small islands between dikes.

Traditionally, side channels and oxbows were closed with rock structures to divert flow into the main channel. Re-opening side channels and oxbows would serve to minimize and rectify project impacts by reestablishing fish access to important habitats used for foraging, breeding, and refuge.

Aquatic Resources: Status of the HEP Analysis and Recommended Mitigation for Disposal Sites and River Training Structures

The interagency evaluation team has developed a mitigation plan based on the following avoidance, minimization, and compensatory features:

- Relocate disposal areas to alternate sites that avoid valuable aquatic habitat;
- Notch dikes and revetments to reduce fill rates and create side channel habitat;
- Re-open connections to oxbows/backwaters and side channels;
- Create islands for aquatic diversity and tern habitat;
- Create marsh habitat at aquatic disposal sites to offset disposal impacts;

The following assumptions were made in developing the plan:

- Alternative disposal sites would be feasible provided they were within one mile of the proposed dredge area;
- Raising dikes and revetments would accelerate filling by 50 percent;
- Notching dikes and revetments would reduce the rate of fill by 50 percent;
- Notches would be one per structure, in the middle third of the structure, 20 feet wide, and to a depth of 3-feet below the normal pool elevation;
- Backwater areas could be reconnected after addressing landowner and section 404/401 Clean Water Act issues;
- Island and marsh habitat could be created where adequate volumes of dredged material allowed; and
- Due to the uncertainty of the success of mitigation features, the Corps and ERDC would develop a long-term monitoring plan and adaptive management strategies through interagency coordination.

Habitat Suitability Index values were determined for the aquatic mitigation sites based on best professional judgment of the biologists on the interagency team. Red Hen flight video footage, local expertise, and familiarity with the areas were used to assist in the selection of HSI values. Acreages for the sites were digitized by the Corps. The results of this interagency effort resulted in a detailed database containing quantitative and qualitative data on impact and mitigation sites.

Dike field impacts would result in an overall loss of 1021.6 AAHU along the entire length of the project. Benefits from approved and partially approved mitigation projects resulted in a gain of 636.8 AAHU. However, the mitigation and avoidance/minimization efforts of the project fail to fully compensate for anticipated project impacts to aquatic resources. The existing HEP analysis indicates a net deficit of 429.4 AAHU (Table 29).

The filling rate coefficient (*i.e.,* rate of fill anticipated to occur in dike fields; see evaluation methods section for more information) used for the current analysis was initially based on dredging maintenance records over the last eight years from Arkansas pools only. The interagency team concluded that filling rates should be derived from dredging maintenance records over the last 24 years for representative pools in Arkansas and Oklahoma to more accurately reflect future conditions. The filling rate coefficients are currently being modified.

Aquatic mitigation features considered to date would result in a net gain of habitat units in Oklahoma, but a deficit in Arkansas. The Little Rock District, Service staff from Arkansas, and the AGFC have recently developed additional and modified mitigation features for the Arkansas portion of the project. Future HEP analysis of impacts and mitigation features should incorporate the new filling rate and the additional mitigation features for the Arkansas portion of the project. Additional and modified compensatory mitigation recommendations for aquatic resource impacts for the Corps consideration during development of the complete mitigation plan is provided in Appendix G. Incorporating these mitigation features into the mitigation plan would serve to adequately offset aquatic resource impacts. The final mitigation plan for aquatic resource impacts would be acceptable to the Service, ODWC, and AGFC provided that it was demonstrated through a HEP or similar analysis to completely offset losses in habitat value over the project life.

Table 29. Aquatic impacts and benefits by project alternative for the Arkansas and Oklahoma portions of the Arkansas River Navigation Project.

	Arkansas	Oklahoma	Total
WITHOUT PROJECT	**5797.8 AAHU**	**782.9 AAHU**	**6580.7 AAHU**
IMPACTS[1]			
11-ft Channel	**- 583.7 AAHU**	**- 35.4 AAHU**	**- 619.2 AAHU**
12-ft Channel	**- 963.1 AAHU**	**- 58.5 AAHU**	**- 1021.6 AAHU**
BENEFITS[2]			
Approved Mitigation			
11-ft Channel	**+ 459.1 AAHU**	**+ 199.0 AAHU**	**+ 658.2 AAHU**
12-ft Channel	**+ 439.4 AAHU**	**+ 197.3 AAHU**	**+ 636.8 AAHU**
Avoid/Minimize			
11-ft Channel	**+ 299.3 AAHU**	**+ 22.8 AAHU**	**+ 322.1 AAHU**
12-ft Channel	**- 43.3 AAHU**	**- 1.3 AAHU**	**- 44.6 AAHU**
NET GAIN/LOSS[3]			
11-ft Channel	**+ 174.7 AAHU**	**+ 186.3 AAHU**	**+ 361.1 AAHU**
12-ft Channel	**- 566.9 AAHU**	**+ 137.5 AAHU**	**- 429.4 AAHU**

[1] With Project AAHU – Without Project AAHU = Impacts AAHU

[2] Mitigation AAHU – Without Project AAHU = Benefits AAHU

[3] Benefit AAHU - Impact AAHU = Deficit/Gain AAHU

Aquatic Resources: Gravel

Gravel bar surveys in proposed dredging locations indicated that 165 acres of gravel substrate potentially could be impacted. Gravel is a finite resource and limited in distribution and abundance within the system. Any impacts from dredging would be a primary concern because of the inherent habitat value of gravel bars. Gravel substrate has been documented as important spawning habitat for numerous species of fish, such as paddlefish, darters, and shovelnose sturgeon. Results from the aquatic habitat impacts analysis illustrates a positive relationship between fish abundance and the amount of gravel and sand/gravel mixture available. It implies that reducing the amount of gravel substrate in the channel through dredging and construction or modification of training structures would have a major adverse impact to fishes.

Conservation of imperiled species and the overall loss of gravel substrates from anthropogenic disturbances fully justify creation or relocation of gravel bars as a mitigation feature. The mitigation goal should be no net loss of pure gravel bars. Appropriate mitigation should involve either relocating gravel that is dredged to a nearby, suitable area or establishing gravel bars by transporting dredged gravel to other more distant but suitable sites within the project area. Through project design modifications and mitigation, important gravel habitats can be conserved and possibly even restored to many locations along the river. Relocation efforts should be followed with long-term monitoring and adaptive management to ensure mitigation features can provide both conservation and restoration of these habitats within this system. Specific recommendations are provided in Appendix G to minimize and rectify impacts to gravel bars over the project life.

Aquatic Resources: Mussels

Dredging and disposal of sediments would directly affect freshwater mussels inhabiting this system. Indirectly, mussels are likely to be impacted by changes in water quality, sediment destabilization, host fish impacts, and increased invasive species introductions. A mussel survey of the MKARNS was conducted in 2004 by Ecological Specialists (Ecological Specialists, 2005). Service comments on the study and recommendations to avoid, minimize, and compensate for freshwater mussel impacts were provided in planning aid letters dated April 29 and May 11, 2005, respectively. These letters can be found in Appendix H.

Many of the anticipated aquatic resources impacts from navigation channel maintenance would be similar in nature to those anticipated from the proposed navigation deepening feature. Potential impacts would include reduction of gravel bar habitat, loss of terrestrial and backwater habitat due to dredged material disposal, changes in water quality, adverse impacts to fish spawning and recruitment, a change in the habitat value of backwater areas (*e.g.,* oxbow lakes and sloughs that provide important waterfowl and fish spawning habitat), morphological changes (*e.g*., channel incision, bank failure, head cutting, and scouring), potential for contaminant re-suspension and relocation within the water column and adjacent habitats that could affect organisms, and continued water quality degradation in lower pools and tailwaters from increased sedimentation, turbidity, and deposition resulting in increased nutrient loading and dissolved oxygen depletion.

Sediment Analysis

The fish and wildlife agencies strongly recommend further analysis of dredged material for contaminants prior to disposal. Specific disposal measures to minimize the environmental impact of disturbance, transport, and disposal of contaminated sediments should be developed and utilized where necessary. The resource agencies should be afforded the opportunity to review and comment on these measures. This issue is not only relevant from the standpoint of impacts to fish and wildlife resources, but also is a public health concern.

The ODWC has specific concerns regarding dredging activities and sediment analysis within the vicinity of the Sequoyah Fuels Corporation Industrial site. Their comments and recommendations can be found in their concurrence letter in Appendix A.

In summary, a complete mitigation plan for terrestrial impacts at disposal sites in Oklahoma has been proposed. Aquatic mitigation features considered to date would result in a net gain of habitat units in Oklahoma, but a deficit in Arkansas. Additional and modified compensatory mitigation recommendations for aquatic resource impacts for the Corps consideration during development of the complete mitigation plan is provided in Appendix G. Incorporating these mitigation features into the mitigation plan would serve to adequately offset aquatic resource impacts.

Many of the effects of this project cannot be mitigated in-kind due to the nature of the project and its impacts. Compensation for impacts occurring from the filling of terrestrial and aquatic disposal areas can and should be achieved by restoring and maintaining habitats that are lost. Loss of main channel gravel shoals may not be adequately mitigated and restored in-kind because these habitats must be dredged and continuously maintained at a 12-foot navigation channel depth. Side channel or out-of-channel gravel substrate and shoals may not naturally be sustained or remain suitable as habitat for some aquatic species. Therefore, out-of-kind mitigation may be necessary to maintain these species within the system.

There are many indirect effects to habitats and species that cannot be quantified or qualified due to time constraints, data limitations, and our lack of knowledge regarding the functions of large river ecosystems and the effects of navigation projects. Initiation of long-term analysis and ecosystem monitoring is necessary to adequately assess potential impacts to fish and wildlife resources (see Environmental Management Program below). Only in time can the necessary data be collected and assessed to fully comprehend and establish correlations indicating the extent of project impacts to habitat, water quality, fish communities, productivity, and individual species.

Should further analysis indicate that adverse impacts to fish and wildlife resources along the river likely would occur, we believe that the mitigation goal for Category 3 resources likely could be met through enhancement and conservation actions throughout the river such as:

- creation and seeding of shallows and backwater areas to restore and enhance habitat lost for migrating waterfowl and fisheries;

- providing ODWC and AGFC funds for the construction and/or enhancement and management of islands, floodplains, green tree reservoirs, marshes, and/or other fisheries and waterfowl resources affected by the project in a coordinated and comprehensive conservation program;

- providing funds for monitoring studies by ODWC, AGFC, and/or ERDC in a coordinated and comprehensive monitoring program to assess impacts, identify correlations, and develop future adaptive management and mitigation options;

- providing funds for fish management, stocking, and habitat mitigation based on future impact assessments and recommendations for maintaining species viability;

- providing funds to ODWC and AGFC or assisting in the restoration and maintenance of in-stream habitat and improvement of habitat diversity by notching dikes, constructing hardpoints, and restoring connections with oxbows and side channels where possible; and

- creating, restoring, and maintaining vegetation free islands at suitable elevations for the least tern along the entire length of the MCKARNS to aid species recovery and guarantee species viability.

In order to adequately assess impacts and to compensate for unavoidable losses, we recommend that the Corps:

- Continue to work with the interagency evaluation team to finalize the aquatic impact assessment. The assessment should determine the quantity (acres) and quality (habitat type and value) of resources that would be impacted and that would require mitigation; and determine the quantity and quality of habitats that would be acquired and/or managed to compensate for habitat losses;

- Implement mitigation for identified and quantifiable impacts by restoring, enhancing, and/or creating substitute habitats within the project area; and develop a long-term coordinated and comprehensive environmental monitoring and assessment program to collect baseline data, identify additional impacts, develop recommendations, and propose future adaptive management and mitigation measures. A conceptual environmental monitoring and assessment program is discussed in more detail below in the section titled Environmental Management Program. We also provide a paper on a conceptual program in Appendix C.

ENVIRONMENTAL MANAGEMENT PROGRAM

The effects of the development, operation and maintenance of the navigation system on the fish and wildlife resources in the study area (including the reservoirs, wildlife management areas, the downstream segments of the rivers, wetlands, backwater areas, and in the main stem of the navigation channel) likely would have long-term consequences that cannot be adequately identified, predicted , or appropriately assessed without long-term studies and extensive

monitoring efforts. Due to the large project area and complex variables that can influence the navigation system, uncertainty is an unavoidable component of managing and maintaining the natural resources associated with this large river ecosystem. For example, predicting weather patterns which ultimately influence fluctuations in river flow and reservoir pool elevations is not possible with complete accuracy. Furthermore, unpredictable potential impacts to the aquatic environment could result from a number of factors: 1) an increase in commercial shipping would increase the risk of potential spills of pollutants (*e.g.*, oil, fertilizers, chemicals, etc.) into the aquatic environment; 2) an increase in municipal and industrial development along the system would increase the number of discharges (point and non-point) into the system and cause direct loss of habitat, 3) dredging and aquatic dredged material disposal would modify the amount and type of fish and wildlife habitat available in impacted areas. These events would alter fish and wildlife resource values associated with this large and dynamic system.

Due to the potential for future impacts to the natural resources associated with the navigation system, sustained, long-term monitoring efforts appear to be warranted (Buchanan, 1976). Section 306 WRDA 1990 made environmental restoration one of the primary missions of the Corps, permitting the Corps to undertake studies and implement projects that restore habitat. Section 906 (b) of WRDA 1986 authorizes the Secretary of the Army to mitigate damages to fish and wildlife resources resulting from any water resource project under Corps jurisdiction, whether completed, under construction, or proposed to be constructed. The long-term studies and monitoring program could serve as an adaptive strategy to: 1) facilitate the development of appropriate conservation measures that would restore and maintain the habitat value of the fish and wildlife resources associated with the navigation system over the project life, 2) assess the true magnitude of the cumulative impacts from the development, maintenance, and continued operation of the system, and 3) identify and address any unanticipated mitigation needs. Assessing unforeseen beneficial and adverse impacts to fish and wildlife resources may be the only guaranteed means to ensure that the important fish and wildlife resource values associated with the system, as discussed throughout this report, are restored and maintained.

Therefore, to maintain and restore the habitat value of the fish and wildlife resources affected by the MKARNS, we recommend that the Corps utilize the authority provided under section 906 (b), WRDA 1986 and section 306, WRDA 1990 to:

1) (a) Seek full Congressional authorization and funding for a Cooperative and Comprehensive Environmental Management Program. The program would be based on long-term monitoring and relevant environmental studies that would occur before, during and following project implementation and extending until such time as sufficient data have been collected to clearly accurately determine the full extent of environmental impacts, establish any needed post project mitigation measures, and develop a coordinated and comprehensive management plan encompassing the life of the proposed project. (Table 30 provides a preliminary example of needed long-term monitoring studies developed by the interagency team to date). The purpose of the program would be to monitor Arkansas River resources to assess project impacts and develop proposed recommendations for adaptive management and mitigation measures. Cooperation and partnerships are essential to effectively assess, comprehend and manage the complexities of this large river ecosystem. The establishment of a coordinated

monitoring program that combines the efforts and resources of local, state, federal, and private natural resource agencies would be ideal. The waters, islands, and floodplain riparian corridor owned by the Corps, along with the NWRs, state wildlife management areas, state parks, and/or non-governmental organization conservation lands comprise an extensive complex of important fish and wildlife resources in the Arkansas River Valley. Coordinated, comprehensive management of these important lands and waters would provide benefits for habitat diversity, species viability, and corridor connectivity that likely could not be achieved by independent management efforts alone.

1) (b) Establish multiple resource monitoring stations along the navigation system as an effective means of meeting the objectives of a monitoring program. Monitoring stations would facilitate the following:

    - Identification and quantification of project impacts to fish and wildlife resources that are attributable to construction and operation of the MKARNS for the entire navigation system (including the upstream reservoirs, rivers, and wetland and terrestrial habitats);

    - Planning to address these impacts and the development of an interagency mitigation plan for any unmet mitigation needs. The mitigation plan should include: a) actions discussed in this report, such as habitat restoration, enhancement, and creation projects within the project area for habitats used by federally-listed species, rare/declining species, and species popular with local anglers and hunters; and b) acquisition of ecologically valuable habitats that are scarce in the ecoregion and/or provide quality fish and wildlife resource-associated recreational opportunities. These lands should be considered for addition to the national wildlife refuge system, state wildlife management areas, or other appropriate natural resource agencies' holdings for fish and wildlife resource management purposes; and

    - Identification of undesirable, on-going or future impacts and trends, unexpected adverse effects, and the necessary remedial actions to compensate for impacts, restore habitat, or reverse undesirable trends.

2) Establish an interagency McClellan-Kerr Arkansas River Navigation System Conservation Committee to coordinate efforts and oversee the Environmental Management Program. The committee would serve to formulate and assist in implementation of plans, studies, and necessary conservation measures designed to enhance, restore, compensate for losses, and maintain the fish and wildlife habitat value associated with the navigation system. A coordinated and comprehensive approach is necessary to effectively manage a large river ecosystem and maintain the corridors and species viability within the system. The committee should be made up of biologists from the ODWC, AGFC, Corps, the Service (refuge and ecological services staff), and experts from local and regional universities. The committee would evaluate reports from the Corps, ODWC, AGFC, and the Service regarding impacts to fish and wildlife resources associated with the system as identified through the Environmental Management Program. Examples include adverse impacts to terrestrial

and/or aquatic resources managed by the ODWC during extreme high and low water years, backwater areas, and gravel shoals. The reports also would include the conservation measures needed to adequately compensate for the loss of fish and wildlife habitat value and to assure continued effectiveness of mitigation features.

3) Establish a mitigation fund that would be utilized to address mitigation needs identified through the long-term monitoring program.

The cost of any long-term monitoring program and the recommended mitigation fund should be considered in the Corps benefit:cost analysis for ARNS. A long-term monitoring program and associated mitigation fund is necessary to ensure adequate compensation for impacts to fish and wildlife resources and to maintain the quality of fish and wildlife resources. Significant benefits to local, state, and regional economies likely could be realized as a result of the Environmental Management Program through an increase in fish and wildlife resource-associated recreational activities within the project area. Outdoor recreation continues to be popular with a large segment of the American people. For example, in 2001, U.S. residents nationwide spent more than $108 billion dollars while pursuing fish and wildlife related activities. In Oklahoma alone, wildlife observers, hunters, and anglers spent over $193, $248, and $476, million dollars, respectively (USDOI and USDOC, 2001). In 2002, over 35 million people visited national wildlife refuges throughout the country. Their expenditures (*e.g.*, lodging, food, equipment, etc.) generated over $809 million in regional economies (USFWS, 2003). An increase in outdoor recreation activities is likely to occur within the project area should the objectives of the Environmental Management Program be realized. Increases in the quality of habitat supporting fish and wildlife populations would lead to more opportunities for outdoor enthusiasts over the 50-year project life.

FISH AND WILDLIFE ENHANCEMENT MEASURES

The Service recommends making every possible effort to operate the MKARNS in a manner that promotes the health and diversity of the various ecosystems associated with and impacted by the MKARNS. Today, there are innovative river structures and concepts that can be used to improve navigation, while still providing positive benefits to the environmental resources of a highly altered area, such as the MKARNS (USFWS, 1982). For example, backwater areas adjacent to the MKARNS, such as sloughs, oxbows, river cutoffs, dike fields, and side channels, that serve as important spawning and nursery areas for many fish species are being negatively impacted or lost due to enclosed dikes, revetments, and accreted sediments blocking connection to the channel. Notching the dikes and revetments allows flow behind the structure to scour out areas that have silted in, and allows fish access to important spawning, nursery, foraging, and flow refugia areas. In addition, geotubes and chevrons could aid in creating braided side channels and diversifying bottom contours and substrates. Creating sand islands on or downstream of these structures could restore least tern habitat in areas where sand islands have been lost due to wave action, reductions in flows, and/or vegetative encroachment.

Table 30. Preliminary list of monitoring needs for the Arkansas River Navigation Project.

Task/Activity	Annual Cost (x1000)[1]
1 – Sediment dynamics in dike fields and backwaters • Bathymetry • Substrate sampling • Lidar, GIS	220
2 – Relationships between fish diversity and physicochemical characteristics of dike fields and backwaters • Seasonal sampling in trend pools • Comparison of notched and un-notch dikes • Comparison of mitigation and reference sites	190
3 - Potamological characteristics of impacted and mitigated gravel bars • Substrate borings and classification • Substrate profiling	110
4 - Seasonal use of gravel bars as fish spawning, feeding, and resting areas • Comparison of natural and mitigated bars • Limited invertebrate sampling	145
5 - Head-cutting of important tributaries • Six tributaries • Establish gages and cross sections	110
6 - Habitat characteristics and fish communities in tributary mouths of the Arkansas River	40
7 – Success of freshwater mussel relocation efforts	undetermined

[1] Costs are based on rates provided by EDRC-EL, and include labor to manage the project, analyze data, and prepare reports.

Efforts to identify potential fish and wildlife habitat enhancement projects in Arkansas began in the fall of 2000 with staff from the AGFC, representatives of Ducks Unlimited, and local anglers. Dike notching to allow water to flow behind the dikes and re-open fish spawning areas in Arkansas began in July 2001. In Oklahoma, potential enhancement and restoration sites have been identified in meetings with representatives from the Service, Corps, and the ODWC. The Service commends the Corps for your participation in these efforts. However, there is still much that could be accomplished. Dike notching in Arkansas has currently ceased due to legal

complications and budget restraints. Additional funding and assistance is needed to continue restoring backwater areas and to improve fisheries, wildlife, and recreational management of this resource. Dredged material disposal can be used to create islands, shallows, and vegetated substrates that improve waterfowl and fisheries habitat. Backwater habitats also can be restored using dredged material and notching dikes. Created islands could serve many purposes, such as habitat for least tern colonies, aquatic vegetation substrates to increase available forage and cover, and as recreation sites for camping and swimming. Some islands could be managed as wildlife habitat to provide forage and cover for many mammals, reptiles, amphibians, and birds, in addition to increasing the available acreage for hunting, bird watching or hiking. We also recommend the Corps continue these enhancement efforts by scheduling a trip on the Verdigris River to conduct a preliminary investigation of potential restoration and enhancement projects for river cutoffs and oxbows.

As a result of the ARNS investigation, an opportunity exists to initiate and develop a coordinated and comprehensive management plan to enhance important wildlife habitat, to improve and restore fisheries habitat, protect riparian buffers, and protect and restore wetlands throughout the entire 445 mile MCKARNS corridor. The management of this system could be improved substantially through a cooperative and coordinated effort among the many state, federal, and private resource agencies and organizations responsible for, or having a stake in, the conservation of the Arkansas River ecosystem. The Corps could initiate this effort as part of the design or mitigation efforts associated with this project to promote the improvement of recreation, management, conservation, and protection of fish and wildlife resources, including five federally-listed threatened and endangered species. Personnel from the Corps, along with the NWRs, state WMAs, state parks, and/or non-governmental organization conservation areas could coordinate their management efforts under one plan for habitat diversity, species viability, and corridor connectivity. This cooperatively managed corridor would 1) be the longest conservation complex in the lower 48 states, 2) manage most of the Arkansas River Valley ecoregion, 3) cross two states, and 4) join two Service regions.

In addition to focusing funds and efforts, this partnership could assist with bio-monitoring of the river; fish, wildlife, habitat, and recreational research and management throughout the system; and provide improved management and habitat conservation for federally-listed threatened and endangered species, other rare species, the sport fishery, migratory birds, and other game and non-game fish and wildlife resources. This complex also would improve recreational opportunities and accessibility along the shorelines of the river by cooperatively maintaining and improving parks, access areas, and adding multi-use facilities. In the end, this partnership could provide the long term coordinated biological assessment the Arkansas River Navigation Project needs, while preserving and enhancing the fish and wildlife resource, accessibility, tourism, economic, and educational opportunities along the Arkansas River. Additional funding may be necessary to make this plan a reality, but having a plan in place that reflects stakeholder needs could assist in achieving the necessary support. A conceptual paper on this type of plan is provided in Appendix C.

The Service, ODWC, and AGFC are excited about the opportunity to enhance fish and wildlife habitat along the navigation system. The Service has published a guide that identifies and

describes numerous enhancement and mitigation techniques that could be used to offset and reduce impacts of the development and maintenance of a navigation channel on large riverine systems (Schnick *et al*., 1982). We recommend utilizing this valuable resource as potential environmental enhancement projects and ideas continue to be developed.

The Service also recommends that the Corps consider restoring and enhancing habitat by acquiring land through fee title interests, conservation easements, flowage easements, or management agreements in habitats that are known to have high values, including lands adjacent to the MKARNS that are susceptible to flooding, but currently being farmed. These properties could be added to state wildlife management areas, to the national wildlife refuge system, or other appropriate land holdings to conserve the environmental resources of the area and be used by the general public.

Enhancement of Recreational Opportunities

Although the Service does not recommend measures to increase recreational values as a means of compensating for losses of habitat value, losses to recreational use that would not be offset through habitat mitigation measures should be addressed through other distinct measures. We provide the following potential measures that could be used to offset project-related human use losses of fish and wildlife resources.

The Service recommends that the Corps consider enhancing recreational opportunities at the NWRs along the navigation system. We provide some current needs at the Sequoyah NWR below. Projects at Holla Bend and White River NWRs also should be investigated in coordination with refuge staff.

a) Fishing/Observation Piers: Permanent piers at the Sandtown Woods parking lot and at Fisherman's Point would provide refuge visitors additional opportunities for fishing, wildlife observation, and photography. The piers should be constructed adjacent to the shoreline and would be about 30 – 40 feet long. The estimated cost of the project is $75,000.

b) Vian Ramp Courtesy Dock and Fishing Pier: The existing courtesy dock at the Vian Public Use area has deteriorated. A new floating or permanently anchored courtesy dock would enhance recreational opportunities for boaters and anglers on the NWR and in Robert S. Kerr Reservoir. The estimated cost of the project is about $75,000.

THREATENED AND ENDANGERED SPECIES

The Corps has determined that proposed changes to the MKARNS as a result of the current study may affect federally-listed threatened and endangered species. The project's potential effects on federally-listed species and measures to avoid and minimize any adverse effects are being addressed separately as part of a formal consultation pursuant to section 7 of the ESA for the following four species: 1) the interior least tern, 2) the American burying beetle, 3) the bald eagle, and 4) the pallid sturgeon.

Because several federally-listed species occur in the project area, the project also offers the Corps an opportunity to carry out section 7 (a) 1 responsibilities, as mandated by the ESA. Section 7 (a) 1 of the ESA requires that all federal agencies use their authorities to carry out programs for the specific purpose of conserving threatened and endangered species. Island construction for interior least terns represents one such opportunity.

UNMET MITIGATION NEEDS

The MKARNS is a large and complex system that impacts rivers, tributaries, oxbows, reservoirs, wetlands, and other important natural resources. The original construction of the navigation project destroyed a considerable amount of highly valuable fish and wildlife habitat along the Verdigris and Arkansas rivers. About 28,200 acres of project lands (Sequoyah NWR, McClellan-Kerr WMA units) were allocated for fish and wildlife management after construction of the MKARNS. These lands are still owned by the Corps, but managed either by the Service, AGFC, or ODWC under license agreement. No Corps funding is provided for ongoing management of these properties.

Losses of fish and wildlife habitat as a result of construction, operation and maintenance of the MKARNS were not evaluated using habitat value as a basis for determining compensation needs. The Service believes it is likely that the total combined habitat value of the impacted areas far exceeds the value obtained from lands established through cooperative agreement to compensate for lost fish and wildlife habitat due to the MKARNS (*i.e.*, the 28,200 acres discussed above).

In addition to lands licensed to the Service, ODWC, and AGFC, some MKARNS lands were classified as "Recreation-Low Density Use" and as "Natural Areas," with the Corps retaining responsibility for management. Decreasing budgets over the past decade have not allowed the Corps to manage these lands effectively, or at a level anticipated during original MKARNS planning efforts. As a result, the expected fish and wildlife resource benefits have not materialized.

Furthermore, since the initial navigation project was completed, many acres of additional impacted lands and waters have been identified. Impacts to these areas were never fully assessed or mitigated for by the initial navigation project. In addition, the proposed project likely would increase the impacts to these areas. The full extent of unmitigated impacts associated with the original project and the current proposed project impacts should be considered within this project assessment and mitigated for appropriately at this time.

Section 906 (b) WRDA 1986 authorizes the Secretary of the Army to mitigate damages to fish and wildlife resources resulting from any water resource development project under Corps jurisdiction, whether completed, under construction, or to be constructed. The Service recommends that the Corps seek Congressional authorization and funding to initiate a study to address unmet fish and wildlife mitigation needs of the original MKARNS project and implement conservation measures previously recommended by the Service. The study should assess the impacts of the original construction and subsequent operation and maintenance of the MKARNS to determine whether existing mitigation is adequate to compensate for losses of fish

and wildlife habitat. Fish and wildlife resource based recreational use and needs should be an integral part of this investigation. Application of HEP and geographic information system databases could be used to assess value of the impacted habitat and that of the existing areas allocated for wildlife management (*e.g.*, Sequoyah NWR, McClellan-Kerr WMAs).

Section 3 (a) of the FWCA provides for the use of project lands for fish and wildlife conservation purposes. The Service recommends the re-allocation of high quality project lands along the navigation system in Oklahoma and Arkansas to fish and wildlife management as potential compensatory mitigation. The Corps cumulatively owns large areas of project lands that provide important fish and wildlife habitat, but currently are not protected from potential adverse impacts, such as disposal as surplus Federal property or future development. These lands include such high value habitats as oxbows, islands, wetlands, and riparian areas. The remaining 23 oxbows and cutoffs along the Verdigris River, for example, comprise the last portions of the river in its natural state. These areas have become some of the most highly productive and essential habitats along the river for many species of fish, waterfowl, and other native fauna. The oxbows and cutoffs provide resting areas for waterfowl and important spawning areas for fish. The bottomland hardwood and riparian forests adjacent to and surrounding these oxbows and cutoffs also provided high quality habitat no longer found along much of the river as a result of the MKARNS project.

Many of the oxbows and cutoffs, however, were not afforded protection from future development at the time of project construction. The Service sought protection for all of these areas because they represented the most valuable remaining habitat along the Verdigris River. During the spring of 1980, Verdigris area industrial interests, including the Arkansas Basin Development Association, requested that the Corps leave all oxbows and cutoffs along the Verdigris River portion of the navigation system open for industrial development. The Corps identified seven oxbows and cutoffs for re-allocation to preclude their industrial development. Ultimately, only four oxbows and cutoffs were re-allocated and provided protection from future development, far short of the habitat conservation level envisioned during MKARNS planning efforts.

The Service and ODWC also recommend that the Corps consider as mitigation lands the thousands of acres of floodplain habitat adjacent to the Verdigris River portion of the navigation system between U. S. Route 412 and State Highway 51 in Oklahoma that have been altered by the development of the navigation system, drained, and converted to agricultural use. These properties represent excellent opportunities for wetland and bottomland hardwood restoration efforts, especially the large contiguous tract of agricultural lands in the Big, Goodhope, and Guinn Bottoms. Section 906 (a) WRDA 1986 and section 3 (c) of the FWCA authorizes the Corps to purchase lands for mitigation purposes. We recommend investigating the feasibility of acquiring fee title interests to lands in this area. The lands could then be licensed or deeded to the ODWC as additions to their wildlife management areas or to the Service as additions to the national wildlife refuge system.

The ARNS presents the Corps the opportunity to provide the needed protection, restoration and enhancement of project lands with high fish and wildlife habitat value and potential, such as the river cutoffs and oxbows along the Verdigris River in Oklahoma and altered floodplain habitat.

LIST OF RECOMMENDATIONS

Section 906 (d) WRDA 1986 requires that all post-1986 Corps projects submitted to Congress have either 1) a specific mitigation plan or 2) a determination that the project will have negligible impacts to fish and wildlife resources. Such mitigation plans should be implemented prior to or concurrent with project construction, as mandated by section 906(a) WRDA 1986. This report has demonstrated that the proposed project would result in substantial impacts to important fish and wildlife resources. These impacts would constitute a significant biological change for which mitigation would be required to offset losses. In view of the information provided, the Service provides the following list of recommendations for the purposes of mitigating adverse impacts to fish and wildlife resources attributable to the ARNS selected alternatives:

1) Minimum Instream Flow Releases: Incorporate minimum instream flow releases (based on Orth and Maughan, 1981) for all system reservoirs into the plan selected for implementation. Minimum flow releases should be conducted in a manner that maintains water quality standards as set by the Oklahoma Water Resources Board.

2) Lake Level Management Plans: Develop and implement lake level management plans for the 11 primary flow modifying reservoirs on the MKARNS in Oklahoma in coordination with the Service and ODWC.

3) Impacts to Floodplain Habitat**:** Identify the specific lands that would receive flood protection benefits, determine the quantity (acres) and quality (habitat type and value) of wetlands that the selected operating plan would alter, determine the quantity (acres) and quality (habitat type and value) of wetlands that would be necessary to compensate for wetland losses, and obtain conservation easements in floodplain areas that would be protected from flooding to deter floodplain development and compensate for losses of wetland habitat.

4) Contaminant Analysis: Conduct additional analyses of dredged material for contaminants prior to disposal. The ODWC has specific concerns regarding dredging activities and sediment analysis within the vicinity of the Sequoyah Fuels Corporation Industrial site, which can be found in their concurrence letter in Appendix A. Disposal measures to minimize the environmental impact of disturbance, transport, and disposal of contaminated sediments should be developed and utilized where necessary. This issue is not only relevant from the standpoint of impacts to fish and wildlife resources, but also is a public health concern.

5) Beneficial Use of Dredged Material and Disposal Sites: Use dredged material to create, rebuild, or enhance island and/or marsh habitats in areas that currently have low habitat quality. As an example, the Sandtown Bottoms area (secs. 6, 7, and 18, T. 11 N., R. 22

E.) within the Sequoyah NWR along the Arkansas River has experienced severe erosion from wind-driven wave action, river current erosion, and wakes from boat/barge traffic. The Service recommends that the Corps investigate the feasibility of using dredged material and structures such as geo-tubes that would provide long-term erosion control and increase the aesthetic and wildlife habitat value of the area by providing a substrate that would facilitate the growth of riparian vegetation.

6) Unavoidable Terrestrial Impacts: Implement the mitigation plan for unavoidable terrestrial disposal impacts in Oklahoma that was developed through interagency cooperation by biologists with the Corps, Service, and the ODWC. The plan was developed to ensure that losses in habitat value, rather than in acres, would be offset over the 50-year project life. The compensatory mitigation plan currently endorsed by the Service and ODWC consists of bottomland hardwood restoration and marsh creation at two sites along the Verdigris River that are currently agricultural fields**.** This plan or an acceptable alternative should be implemented prior to, or concurrent with, project construction as mandated by section 906 (a) WRDA 1986. Alternative mitigation plans would be acceptable to the Service and ODWC, provided that the plan 1) was developed through interagency coordination, and 2) demonstrated that losses in habitat value were fully offset over the project life through a HEP or similar analysis. Specific details for bottomland hardwood and marsh restoration/creation, such as tree plantings and exact measures to restore hydrology, should be finalized through interagency coordination with the Service and ODWC.

7) Impacts of Aquatic Dredged Material Disposal and the Construction/Modification of River Training Structures in Oklahoma and Arkansas**:** The Corps, Service, ODWC, and AGFC have been in constant and frequent coordination regarding the assessment of impacts the navigation channel deepening would have on aquatic fish and wildlife resources. Unfortunately, due to the extremely expedited schedule for this study, the aquatic impacts analysis has not been completed as of the date of this report. The Corps should continue to work with the interagency evaluation team to assess the impacts of the project on aquatic fish and wildlife resources.

8) Mitigation Plan for Aquatic Impacts**:** The Corps should continue to work with the interagency evaluation team to develop a complete compensatory mitigation plan that would offset losses to habitat value over the 50-year project life caused by dredging, river training structures, and disposal of dredged material in aquatic sites in Oklahoma and Arkansas. This report provides additional and modified mitigation recommendations for the Corp's consideration during development of the final mitigation plan (Appendix G). We believe incorporating these recommendations into the final plan would help ensure that losses of aquatic habitat value would be adequately offset. The final mitigation plan for aquatic resource impacts would be acceptable to the Service, ODWC, and AGFC provided that it was demonstrated through a HEP or similar analysis to completely offset losses in habitat value over the project life.

9) Impacts to Freshwater Mussel Communities: Implement mitigation measures to avoid and minimize impacts to freshwater mussel concentrations. The Service's Arkansas and

Oklahoma Ecological Services field offices provided recommended mitigation measures for freshwater mussels in planning aid letters dated April 29 and May 11, 2005, respectively.

10) General Plans for Terrestrial Mitigations Sites: In accordance with section 3 and 4 of the FWCA, the Service requests that the Corps begin coordination with the Service and the ODWC on the development of a General Plan (*i.e.*, agreements that make project lands available to the Service or State for fish and wildlife management purposes) for the terrestrial mitigation sites.

11) Operation and Maintenance Funds for Compensatory Mitigation Lands**:** Maintaining the habitat value of compensatory mitigation lands likely will require on-going maintenance and management efforts. Without these efforts, the habitat value of the lands is likely to decrease and fail to meet mitigation goals. Losses in habitat value as a result of the project, therefore, would not be adequately offset by intended mitigation. In accordance with section 2 (d) of the FWCA, costs to carry out fish and wildlife conservation measures are to be considered project costs. Furthermore, section 906 (c) WRDA 1986 states that the costs of fish and wildlife mitigation are to be cost-shared at the same rate as the project purpose causing the impact. Navigation projects are fully federally-funded. The Corps should seek full Congressional authorization and funding for Operation and Maintenance (O and M) needs. These funds should be provided to the managing entity on an annual basis. An O and M budget should be developed in cooperation with the managing entity prior to project implementation.

12) Environmental Management Program, Conservation Committee, and Mitigation Fund: Seek full Congressional authorization and funding for an Environmental Management Program. The effects of the modifications to river flow management and channel depths, and the continued operation and maintenance of the navigation system on the fish and wildlife resources in the study area (including the reservoirs, wildlife management areas, downstream segments of the rivers, wetlands, backwater areas, and the main stem of the navigation channel), likely will have long-term consequences that cannot be adequately identified or appropriately assessed without long-term studies and extensive monitoring efforts. The Service believes the Corps should utilize the authorities provided under section 906(b) WRDA 1986 and section 306 WRDA 1990 to seek full Congressional authorization and funding for an Environmental Management Program. This would enable the Corps to perform long-term studies and monitor fish and wildlife resources associated with the navigation system that would occur before, during and following project implementation and extending until sufficient data have been collected to clearly and accurately determine the full extent of environmental impacts. The long-term monitoring program would serve to 1) facilitate the development of appropriate conservation measures that would maintain and restore the habitat value of the fish and wildlife resources associated with the navigation system, 2) assess the ultimate magnitude of the cumulative impacts from the proposed modifications to channel depths and river flow management, and from maintenance and continued operation of the system, 3) identify and address any unmet mitigation needs not identified as a result of the expedited

study schedule, 4) coordinate and comprehensively manage and improve recreation, fisheries, wildlife, and natural resource conservation throughout the system, and 5) improve the efficiency and maximize resource potential through cooperative operation and management of the system. The Service believes that it would be necessary to establish a mitigation fund that would be utilized to address mitigation needs identified through the long-term monitoring program. Due to the necessity of the long-term monitoring program and mitigation fund to ensure adequate compensation is provided for impacts to fish and wildlife resources and to maintain and restore habitat value, the cost of the long-term monitoring program and the mitigation fund should be considered in the Corp's benefit:cost analysis for ARNS. Benefits to local, state, and regional economies as a result of the likely increase in expenditures for outdoor recreational pursuits (*e.g.*, wildlife photographers/observers, hunters, and anglers) also should be considered in the analysis. A paper on a conceptual Environmental Management Program is provided in Appendix C.

13) Invasive Species**:** The Corps should continue public awareness efforts to increase knowledge and concern about the spread of the zebra mussel and other invasive species by distributing outreach materials that summarize the life history of these species, the adverse environmental consequences caused by their establishment, and recommended measures to help prevent the further spread of these species. This material should be available at project offices and boat ramps throughout the navigation system. The Service also recommends that the Corps consider installing washing and scrubbing stations that provide appropriate water solution and temperature (*e.g.,* a 10 percent water and chlorine solution and water temperatures of 140^{o} F) for removal of zebra mussels at appropriate locations on all reservoirs that support the navigation system to help prevent further spread of zebra mussels.

14) Unmet Mitigation Needs: The Corps should seek full Congressional authorization and funding to initiate a study to identify and address any unmet mitigation needs of the original project. The study should assess the impacts of the original construction and subsequent operation and maintenance of the MKARNS to determine whether existing mitigation is adequate to compensate for losses of fish and wildlife resources.

15) Enhancement/Restoration of Fish and Wildlife Habitat: The Service recommends that the Corps continue efforts to identify and implement potential fish and wildlife habitat enhancement projects in Arkansas and Oklahoma, such as bottomland hardwood restoration and dike notching projects.

16) Endangered Species: Implement projects under authority of section 7 (a) 1, as mandated by the ESA, to help conserve threatened and endangered species, such as island creation and management for interior least terns.

SUMMARY AND POSITION OF THE SERVICE

The project area contains a variety of high quality fish and wildlife resources. These resources include wetlands, bottomland hardwoods, floodplain forest, backwater areas such as oxbows, several streams and rivers, numerous reservoirs, wildlife management areas, and national wildlife refuges. The effects of modifying the current operating plan were evaluated using the Corps "Southwestern Division Modeling System for the Simulation of the Regulation of a Multipurpose Reservoir System," also known as the SUPER Model. For this study, reservoir elevations and river stages were modeled using 61 years (January 1940 – December 2000) of stream flow data. Information obtained from the SUPER Model for each non-structural alternative included 1) average annual river flow and condition, and 2) average annual reservoir stages and duration.

Reservoir level fluctuations are expected to change only slightly from current operations under the selected plan. Impacts to fish and wildlife resources at the reservoirs would not likely differ significantly from current conditions based on average annual lake levels and stream flows. The Service believes, however, that conditions that would occur during extreme high and low years (rather than only on average annual lake levels and river flows) also should be considered in order to appropriately consider potential effects to fish and wildlife resources. These effects are not likely to be evident from an analysis based on average annual reservoir levels and stream flows. Conditions that occur during these extreme years could significantly affect fish and wildlife resources.

Impacts could include altering the littoral zone, eliminating or reducing vegetated areas adjacent to the reservoirs, adversely impacting fish spawning and recruitment, and reducing available habitat for migratory birds. We believe that the mitigation goal for the fish and wildlife resources associated with the 11 primary flow modifying reservoirs in Oklahoma could be met through pro-active conservation actions and adaptive management. Examples are lake level management plans, minimum in-stream flow releases, and monitoring to identify any needed management alterations.

The selected River Flow Management alternative would reduce the duration of over bank flooding in the floodplain. Because the hydrology of floodplain wetlands would be altered, important wetland habitats may be adversely impacted. Therefore, the Service recommends that the Corps identify the specific lands that would receive flood protection benefits, assess adverse impacts to habitat value, and provide compensatory mitigation for unavoidable wetland-related impacts.

Deepening and maintaining the navigation channel would have significant adverse impacts on important fish and wildlife resources. Potential impacts are diverse but primarily would include the direct loss and degradation of terrestrial and aquatic habitat through dredging and dredged material disposal, and degradation of backwater habitats. An assessment of adverse impacts and a complete mitigation plan have been developed for impacts due to disposal of dredged material at terrestrial sites in Oklahoma. The Corps, Service, ODWC, and AGFC have been in constant and frequent coordination regarding the assessment of impacts the navigation channel deepening

would have on aquatic fish and wildlife resources. Unfortunately, due to the extremely expedited schedule for this study, the aquatic impacts analysis has not been completed as of the date of this report.

The Service understands that the Corps intends to fully mitigate for aquatic resource impacts. The Service provides additional and modified compensatory mitigation recommendations for aquatic resource impacts for the Corps consideration during development of the complete mitigation plan in Appendix G. We believe that incorporating these mitigation features into the mitigation plan would serve to adequately offset aquatic resource impacts. The final mitigation plan for aquatic resource impacts would be acceptable to the Service, ODWC, and AGFC provided that it was demonstrated through a HEP or similar analysis to completely offset losses in habitat value over the project life.

The effects of the development, operation, improvement, and maintenance of the navigation system on the fish and wildlife resources in the study area (including the reservoirs, wildlife management areas, the downstream segments of the rivers, wetlands, backwater areas, and the main stem of the navigation channel) will have long-term consequences that cannot be adequately identified or appropriately assessed without long-term studies and extensive monitoring efforts. The Service believes the Corps should perform long-term studies to assess the true magnitude of the development, operation, and maintenance of the MKARNS on important fish and wildlife resources. These further studies also would help identify and address any unfulfilled or unanticipated mitigation needs.

Fish and wildlife resources and associated recreational activities are an important aspect of American culture. In 2001, for example, U. S. residents spent more than $108 billion dollars while pursuing fish and wildlife related recreational activities. In Oklahoma alone, wildlife observers, hunters, and anglers spent $193,248, 000, $248,071,000, and $476,019,000, respectively (USDOI and USDOC, 2001). The Service's overall goal is to conserve these important fish and wildlife resources for the benefit of the American people, while facilitating balanced development. This goal is supported by language in the FWCA. The FWCA establishes fish and wildlife conservation as a coequal purpose of water resource development projects and states that fish and wildlife resources shall receive equal consideration with other features of water resources development programs.

Section 906 (d) of WRDA 1986 requires that all post-1986 Corps projects submitted to Congress must have either 1) a specific mitigation plan or 2) a determination that the project will have negligible impacts to fish and wildlife resources. This mitigation plan should be implemented prior to, or concurrent with, project construction as mandated by section 906(a) WRDA 1986. We have demonstrated in this report that the proposed project would result in substantial impacts to important fish and wildlife resources. These impacts would constitute a significant biological change for which mitigation would be required to offset losses.

Therefore, the Service believes that in order to ensure that fish and wildlife resources receive equal consideration, as mandated by the FWCA, the Corps should:

- Continue to work with the interagency team to fully assess potential impacts to terrestrial and aquatic fish and wildlife resources, and develop a specific mitigation plan through interagency coordination that would avoid, minimize and compensate for project impacts;

- Utilize the authorities provided under section 906(b) WRDA 1986 and section 306 WRDA 1990 to seek full Congressional authorization and funding for an Environmental Management Program in order to perform the long-term studies and monitoring of the fish and wildlife resources associated with the navigation system. The long-term monitoring program would serve to 1) facilitate the development of appropriate conservation measures that would maintain and restore the habitat value of the fish and wildlife resources associated with the navigation system, 2) assess the true magnitude of the cumulative impacts from the proposed modifications to channel depths and river flow management, and from maintenance and continued operation of the system, 3) identify and address any unfulfilled or unanticipated mitigation needs not identified due to the expedited study schedule, 4) coordinate and comprehensively manage and improve recreation, fisheries, wildlife, and natural resource conservation throughout the system, and 5) improve the efficiency and maximize resource potential through cooperative operation and management of the system; and

- Establish a mitigation fund that would be utilized to address mitigation needs identified through the long-term monitoring program. Due to the necessity of the long-term monitoring program and mitigation fund to ensure adequate compensation for impacts to fish and wildlife resources, the Service strongly believes that the cost of the long-term monitoring program and the mitigation fund should be considered in the Corps benefit:cost analysis for ARNS. Benefits to local economies attributable to expenditures for outdoor recreational pursuits, such as wildlife observation, hunting, and fishing, also should be considered.

The Service could support the recommended change to river flow management and deepening of the navigation system up to a 12-foot navigation depth, provided that appropriate mitigation measures that would serve to offset losses in aquatic and terrestrial habitat value, such as those developed by the interagency team and recommended in this report, are implemented. We further believe that an Environmental Management Program and Mitigation Fund should be established to ensure that adverse effects continue to be rectified over time and that unidentified mitigation needs could be met. The cooperation of the Corps during our investigation of the proposed action is greatly appreciated.

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